User Role in the VV&A of Legacy Simulations

RPG Core Document

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Field Code Changed

This document corresponds to the web version of the VV&A RPG Core Document of the same name and date. It has been modified to make it suitable for printing. This document replaces the 8/15/01 version. It contains updated material and formatting changes.

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Introduction

What Is the Role of the User in Legacy Simulation VV&A?

This document describes the role and responsibilities of the User in the verification, validation, and accreditation (VV&A) of a legacy simulation.[1] ***User*** is the term used throughout the RPG to represent the organization, group, or person responsible for the intended application. The User defines the problem, determines the approach that will be used to solve it, and accepts and uses the results. When modeling and simulation (M&S) are used, the User defines the M&S requirements that determine what the simulation is expected to do and makes the accreditation decision. When a legacy simulation is used, the User is the one responsible for selecting the simulation. In the home-buying analogy presented in *Key Concepts*,[2] the User represents the prospective owner.

Other roles that perform and support legacy simulation VV&A include

- **Accreditation Agent** – the role responsible for conducting the accreditation assessment
- **V&V Agent** – the role responsible for providing evidence of the simulation's fitness for the intended use by ensuring that all the necessary V&V tasks are properly carried out
- **M&S Program Manager** – the role responsible for managing the modification of the simulation for the intended use, when needed
- **Developer** – the role responsible for providing technical expertise regarding simulation capabilities, for preparing data for use in the simulation, and for making code modifications and developing new code, when needed
- **M&S Proponent** – the role responsible for managing the legacy simulation throughout its lifecycle, including configuration management, application, and maintenance, and for approving all modifications to the authorized version of the simulation[3]

These roles can be filled in a variety of ways, such as

- each role performed by a different individual, group, or organization
- several roles performed by the same individual, group, or organization
- all the roles performed by the same individual, group, or organization

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[1] Throughout this document the term *simulation* is used to denote either a model or a simulation and the term *legacy simulation* is used to denote a model or simulation that has been used previously or was developed for a different application.
[2] See the RPG menu item *Key Concepts* for additional information.
[3] Note that the M&S Proponent role is responsible to the simulation program.

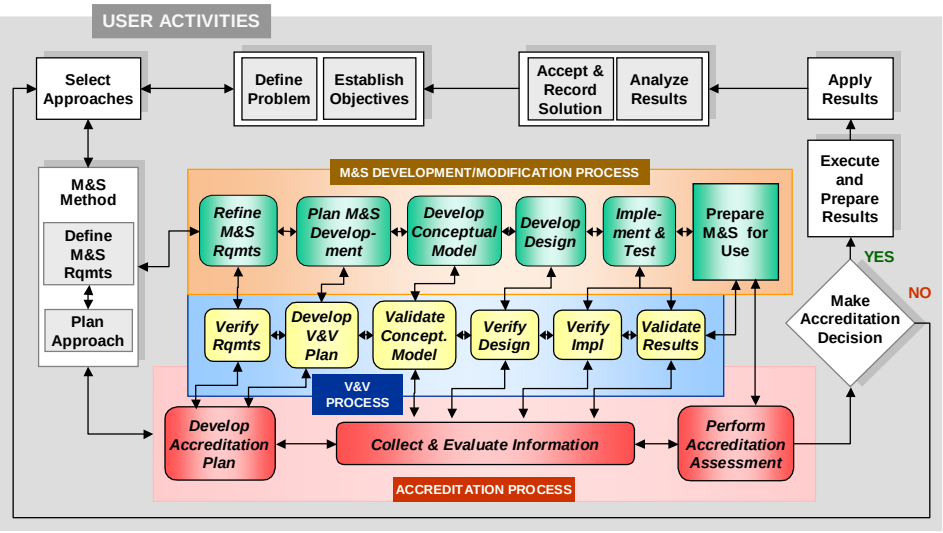
The number of performers required for a given application is predicated on the needs of the application, the amount of work required in each role, the availability of resources, and the risks involved. When extensive simulation modifications are needed or when the issues being addressed involve critical concerns (e.g., health, safety), it is more likely that a separate individual, group, or organization will be designated for each role. When the pedigree of a legacy simulation is well documented, and the simulation has been used for similar applications in the past, and requires little or no modification, it is likely that some roles may be performed by the same individual or group. For example, the User may serve as the M&S PM, Developer, V&V Agent, and/or Accreditation Agent.

The User wants the results of the legacy simulation to be plausible, realistic within the confines of the problem being addressed, and credible. The intent of the overall VV&A effort is to provide evidence about the fitness of the simulation to serve the User's purpose. Ultimately, the User decides whether the simulation is credible enough to use.

How Does This Differ from the User Role in New Simulation VV&A?

In the VV&A of both new and legacy simulations, the User performs a number of activities that impact the VV&A effort. The User is responsible for defining the problem, determining what methods will be used to resolve it and for accepting and using the results of the simulation. In between, the User supports the VV&A effort by providing guidance and serving as the final decision maker for all issues that impact the ability of the simulation to address the intended application. The fundamental differences in the User's role in the VV&A of new and legacy simulation arise in the types of information needed for decision-making, how and when information is acquired and assembled, and the challenges involved in obtaining it.

In the figure below, which depicts the User's involvement in the VV&A process for new simulations, the principal User activities, depicted as shadowed boxes, appear in the outer (problem solving box). These activities are performed regardless of whether a new or legacy simulation is involved. The difference in the User role occurs because a new simulation is developed to address the specific requirements of the (User's) intended application. The User is able to focus and shape the development of the simulation by serving as primary decision-maker throughout the development process. The Developer building the new simulation and the M&S Program Manager (PM) managing its development are accessible throughout the development process and V&V activities are coordinated with development activities to ensure decisions regarding the development can be made in a timely manner. Any problems that arise can be resolved in a variety of ways, through changes in the simulation design, or in the requirements to be addressed.



User Involvement in the VV&A of New Simulations

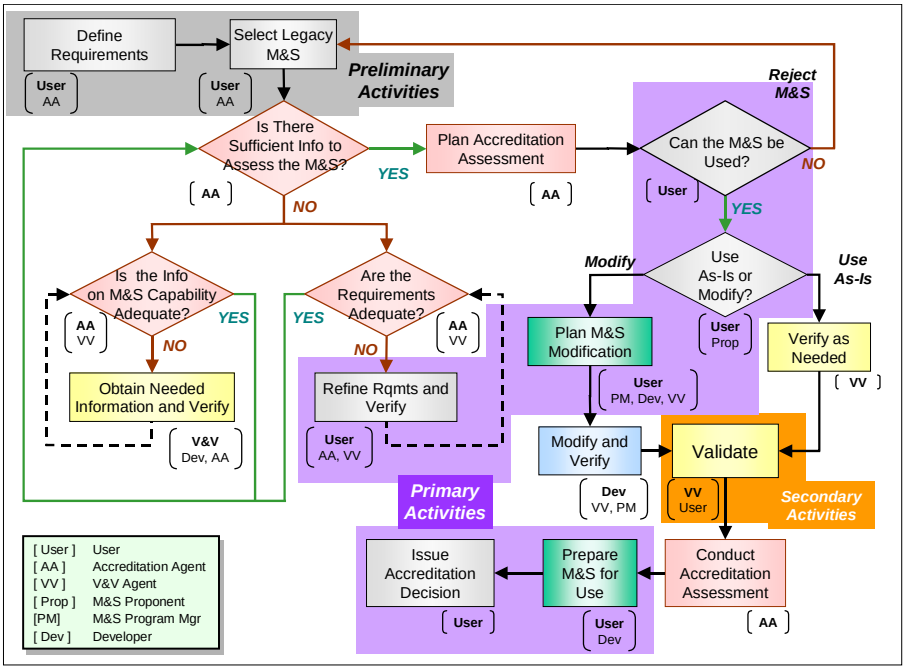
When using a legacy simulation, as described in the *Legacy Simulation Overview*,[4] the User does not have the ability to shape the development of the simulation and is faced with the challenge of using a simulation that was built to address a different purpose. The requirements that the simulation has addressed in previous usage may or may not correspond to the requirements of the intended application and its history of usage may or may not have much in common with the intended use. Moreover, if the simulation must be modified, the User may need to obtain permission from the M&S Proponent to do so. The difference between previous usage and the intended application, the differences between the simulation's existing capabilities and the capabilities needed to address the User's requirements, and the availability of quality information about the simulation and its history will determine the extent of the User's involvement in the overall VV&A effort.

User involvement in the VV&A of a legacy simulation can be grouped into three sets of activities shown in the following figure[5] and listed below.

- **Preliminary activities** that lay the foundation for the VV&A effort (shaded in gray in the figure)
- **Primary activities** that support the VV&A effort (shaded in purple in the figure)
- **Secondary activities** performed as needed to support the VV&A effort (shaded in orange in the figure)

[4] See the core document on the VV&A of Legacy Simulations Overview.
[5] Based on the flow diagram in the VV&A of Legacy Simulation Overview.

These activity groupings are used in the remainder of this document to facilitate discussion of the User's responsibilities and functions.



User Involvement in Legacy Simulation VV&A

VV&A Responsibilities of the User Role

The User is responsible for defining the overall application. In the beginning, the User defines the problem, establishes the objectives, and selects the methods to be used in solving the problem. When M&S is the approach selected, the User defines the M&S requirements,[6] conducts the problem analysis to identify the risks involved, and conducts or participates in the risk assessment[7] to focus the accreditation and V&V efforts. In the end, the User is responsible for making the accreditation decision.

Because of the risk involved in making decisions based on erroneous simulation results, the User relies on the V&V and accreditation efforts to provide evidence that the simulation can yield credible results. The results of these efforts also help reduce the risk to an acceptable level. The VV&A evidence provides information on the ***fitness*** of

[6] See the special topic on Requirements for additional information.
[7] See the special topic on Risk and Its Impact on VV&A for additional information.

the simulation for the intended application and on the potential risks associated with that use.

Key factors determining the fitness of a simulation for a given application are

- ***Capability* --** what the simulation can do in terms of functional representations, behaviors, relationships, and interactions
- ***Correctness* –** error-free code; appropriate authoritative input data
- ***Accuracy* --** how closely the results correspond to the intended view of reality (i.e., the referent)
- ***Usability* --** the existence and sufficiency of user-support features (e.g., manuals, training) which will enable the User to properly execute the simulation and analyze and/or employ the results

> Example:
>
> Even if the model is a simple algorithm, such as an amortization table from the financial analysis community, the User needs to know that the answers produced (e.g., the payments and interest accrued) are correct.
>
> For more complex simulations, such as an aircrew trainer, a much more rigorous VV&A effort would be needed to ensure the simulator provides an environment that leads the aircrew member to desired learning outcomes. Precise 'look' and 'feel', as well as other fidelity issues would be very important aspects of V&V for this class of simulation.

While many of the associated tasks can be delegated, in the end, the User is the accreditation authority and will make the accreditation decision by choosing one of the five possible options:

- **Full accreditation --** the simulation produces results that are sufficiently credible to support the application
- **Limited or conditional accreditation --** constraints should be placed on how the simulation can be used to support the application
- **Modification of the simulation is needed** -- the simulation's capabilities are insufficient to support either full or conditional accreditation; modifications and subsequent V&V are needed to correct the deficiencies
- **Additional information is needed** -- the information obtained about the simulation is insufficient to support either full or conditional accreditation; additional information should be generated or otherwise obtained, supplemental verification, validation and/or testing should be conducted to provide the necessary information before the accreditation decision is made
- **No accreditation --** the results of the assessment show that the simulation does not adequately support the application

For complex simulations, a rigorous examination of those aspects of the simulation considered most critical to the intended application is necessary to provide the information the User needs to make an informed accreditation decision.

The User is the final decision maker for all issues that impact the ability of the simulation to address the application (e.g., changes affecting success criteria, requirements, objectives). If changes occur that impact the problem objectives and M&S requirements, the User should ensure that the modified requirements are communicated to the Accreditation Agent, V&V Agent, Developer, and M&S PM so plans, activities, and schedules can be adjusted to accommodate the changes. If these changes will result in modifications to the authorized version of the simulation, the User also coordinates with the M&S Proponent to ensure that the modifications are acceptable. Likewise, the User should be actively involved in every phase of a simulation development effort, to ensure that the myriad of decisions made in such efforts reflect the User's priorities and issues.

The User is also the motivating force for the accreditation effort and provides support for the V&V effort. The User should establish the boundaries of the overall accreditation assessment based on the critical elements that pertain to the objectives of the application and acceptable risk, guide the planning and resource allocation of the accreditation process, and monitor its implementation. The User should work with the V&V Agent, Accreditation Agent, and M&S PM to ensure the V&V effort is appropriately focused and sufficiently robust, and should provide subject matter expertise as needed.

The User should not assume the previous V&V performed on the simulation is sufficient for the intended use. Even minor changes in the application of a simulation (e.g., changes in the values of input or hard-wired data, new scenarios, new force structures, different threat, different priorities) can have a profound effect on the validity of simulation results.

An approach to oversight of the VV&A effort that has worked well in the past is the formation of an Integrated Product Team (IPT) or similar working group. This team normally is made up of the User, Developer, V&V Agent, Accreditation Agent, and M&S PM and is supported by subject matter experts (SMEs)[8] as needed. The goal of the team should be to ensure the focus remains on the most critical issues and the team should act to modify plans and tasks accordingly. The team should conduct regularly scheduled interchange meetings as well as separate, focused problem-solving sessions and produce regular reports.

The following table summarizes the typical User responsibilities associated with different functions and activities involved in the VV&A of a legacy simulation.

[8] See the special topic on Subject Matter Experts and VV&A for additional information.

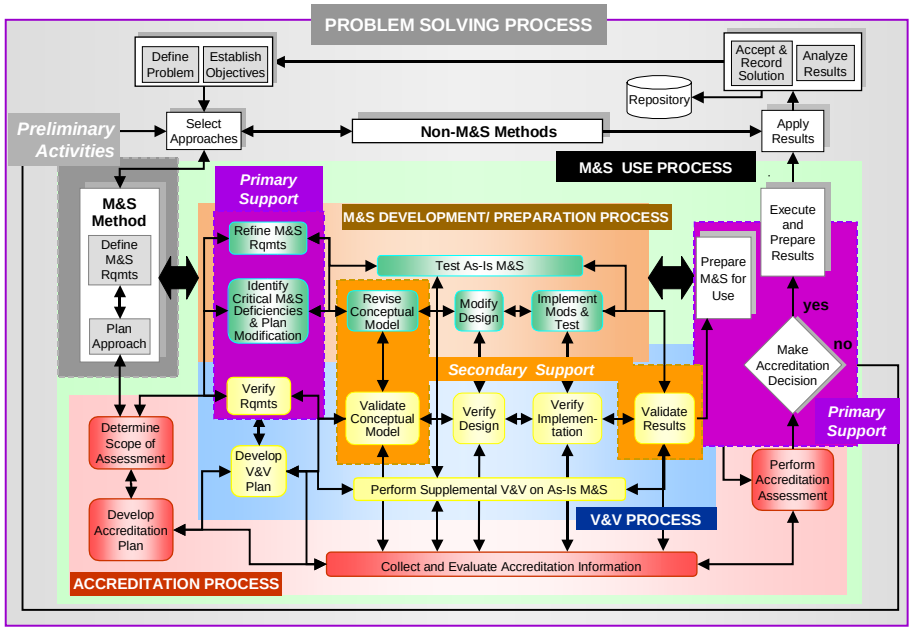
User Involvement	User Function	Typical User Responsibilities
Preliminary Activities	Define problem and establish objectives [p. 9]	• provide a problem statement that identifies the issues to be resolved and the objectives that have to be met
Preliminary Activities	Define M&S requirements [p. 10]	• provide the set of requirements and objectives that define the problem to be solved
Preliminary Activities	Select simulation [p. 12]	• select the simulation to use
Preliminary Activities	Develop scenarios [p. 11]	• provide scenarios, use cases, environments, situations, etc. that describe how the simulation entities, behaviors, and interactions should be represented to help solve the problem
Preliminary Activities	Designate Accreditation Agent [p. 16]	• designate Accreditation Agent with appropriate experience (e.g., knowledge of problem and user domains; experience with accreditation assessment techniques) to conduct the accreditation assessment
Preliminary Activities	Identify risks [p. 14]	• conduct and support risk assessments to determine what risks might result from erroneous simulation outputs
Preliminary Activities	Select SMEs [p. 17]	• select SMEs to assist with problem definition, simulation modification and V&V activities
Preliminary Activities	Define measures of success [p. 12]	• help select appropriate measures and define acceptability criteria[9] that that each M&S requirement must meet
Primary Support	Identify data sources [p. 16]	• identify appropriate, authoritative sources for data needed by the simulation
Primary Support	Refine M&S requirements [p. 20]	• provide a complete and concise set of requirements and objectives to refine the problem to be solved
Primary Support	Support requirements verification [p. 20]	• serve as a subject matter expert (SME) for the user and problem domains
Secondary Support	Support conceptual model modification and validation [p. 27]	• serve as an SME for the user and problem domains and accept the validated conceptual model
Secondary Support	Support validation [p. 27]	• serve as an SME for the user and problem domains to prepare appropriate test cases, provide validation data, and participate in the evaluation of results
Secondary Support	Verify user documents [p. 28]	• review user manuals, documentation, etc.
Primary Support	Make accreditation decision [p. 26]	• make the accreditation decision based on the evidence provided by the V&V information and accreditation assessment

[9] A set of standards that a particular model, simulation, or simulation federation must meet to be accredited for a specific purpose. Acceptability criteria should specify measurable performance in user, simulation, and problem domains [RPG Glossary].

VV&A Functions of the User Role

The Overall Problem Solving Process

The use of a legacy simulation represents one path in the overall problem solving process. This path may have significant advantages if a simulation exists with sufficient capabilities to address the User's needs. The figure below depicts legacy simulation in the Overall Problem Solving Process.[10] The three sets of User activities identified in the User Involvement flow diagram [p. 4] are superimposed on this figure to illustrate their place in the overall process.



User Involvement in the VV&A of Legacy Simulations

The User's impact on the legacy simulation VV&A effort starts at the very beginning of the Overall Problem Solving Process and continues with every major decision until the accreditation decision is made. The User initiates the entire problem solving process by first defining the problem and establishing the objectives to be met for its solution, and then proceeds by selecting the approach (e.g., modeling and simulation, experimentation, statistical analysis, live testing) that will be employed to resolve it.[11]

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[10] For a complete description of the overall problem solving process, see the Key Concepts.

[11] The diagram separates approaches into M&S methods and non-M&S methods. This Guide assumes the selection of M&S methods; Non-M&S methods that may be chosen to address all or part of the overall problem are beyond the scope and will not be addressed.

The User completes the overall process by applying the methods (e.g., making the decision to accredit the simulation for use, running the simulation, accepting the simulation results) and analyzing, accepting and recording the overall solution. How well these activities are performed, particularly those at the beginning, is critical to the success of the entire process.

The remainder of this section discusses the tasks and functions that comprise the User activities affecting the VV&A of a legacy simulation. To facilitate this discussion, the tasks and functions are presented grouped as illustrated in the process and flow diagrams:

- Preliminary User Activities [p. 9]
- Primary User VV&A Support Activities [p. 18]
- Secondary User VV&A Support Activities [p. 26]

Preliminary User Activities

The activities performed at the beginning of the overall problem solving process establish the foundation for assessing and preparing the simulation for use. The specific functions affecting the VV&A effort during these activities include:

- Define the Problem and Establish Objectives [p. 9]
- Analyze the Problem [p. 10]
- Define M&S Requirements [p. 10]
- Develop Scenarios [p. 11]
- Identify Measures of Success [p. 12]
- Select Legacy Simulation [p. 12]
- Analyze Risk and Uncertainty [p. 14]
- Designate Accreditation Agent [p. 16]
- Designate M&S PM [p. 16]
- Identify Authoritative Data Sources [p. 16]
- Establish Overall Strategy [p. 17]
- Designate SMEs [p. 17]

Define the Problem and Establish Objectives

In defining the problem, the User should first identify the issues involved and establish the objectives that have to be met to solve the problem by addressing the following basic questions.

Problem Domain Questions
• What is the basic problem to be solved? What are the objectives? What questions need to be answered?
• What particular aspects of the problem will the simulation be used to help solve? What is the application?
• What is the scope of the problem? What boundaries or mission space apply?
• What decisions will be made based on the simulation results?
• What risks might result from accepting erroneous simulation outputs or making decisions based on them?

Analyze the Problem

To ensure that a given problem is thoroughly addressed, the User may need to conduct a problem analysis. Typical steps to follow include:

- decompose the problem statement and objectives into discrete M&S requirements
- identify the major representations required to address each requirement, including the entities and interactions implied in each
- identify the fidelity needed to represent each interaction[12]
- identify the metrics or types of measures[13] needed to assess the simulation's ability to satisfy the objectives and requirements and the data the simulation needs to address them
- identify the categories of input data[14] needed to support each major representation
- identify and prioritize the representations that appear least likely to meet their requirements (i.e., identify the risks)[15]

The User should conduct the initial problem analysis as part of establishing the objectives and defining the M&S requirements. However, as more information becomes available, additional analyses should be conducted to ensure simulation preparation and the V&V and accreditation efforts continue to focus on the priorities and the needs of the application.

Define M&S Requirements

[12] See the special topic on Fidelity for additional information.
[13] See the special topic on Measures for additional information.
[14] See the reference document on Data Concepts and Terms for additional information.
[15] See the special topic on Risk and Its Impact on VV&A for additional information.

The M&S requirements[16] of the application are the primary drivers of legacy simulation assessment (including legacy simulation selection, the V&V effort, and accreditation assessment). The User defines the M&S requirements from the user and problem domains, focusing on what is needed to solve the problem, and assists the Developer and M&S PM in defining simulation domain requirements that identify what is needed by the simulation to address the problem. The User makes all decisions that may involve modifications or adjustments to the M&S requirements resulting from the limitations of the simulation.

The User needs to ensure the Accreditation Agent, Developer, and M&S PM have a clear understanding of the requirements and objectives in order to be able to first assess the capabilities of the legacy simulation and then determine what should be done to increase its fitness for the intended purpose. Without clearly articulated requirements, every aspect of legacy assessment and preparation is made more difficult and error prone and the resulting simulation is less likely to address the User's needs.

Problem analysis and ***Risk assessment***[17] are complementary processes used to identify areas of risk and potential showstoppers with the legacy simulation. Problem analysis [p. 10] is conducted to ensure the problem is adequately defined by the M&S requirements (i.e., the right problem is being addressed) and appropriate metrics and acceptability criteria are identified for each requirement. Risk assessment [p. 14] is performed to identify risks which, in turn, are used to establish the priorities used in planning (i.e., accreditation planning, V&V planning, modification planning) to ensure the simulation is fit for the intended application.

Develop Scenarios

One proven strategy for discovering and capturing simulation requirements is by characterizing the scenarios (identifying locations to be used, environmental conditions, players, equipment, organizational structures, courses of action, assumptions, constraints, etc.). Scenarios help establish the scope of the problem by bounding such aspects as environmental concerns and the entities, and behaviors to be represented. In addition, scenarios

- determine what fidelity is needed in the simulation
- serve as the basis for the simulation conceptual model
- are used during testing and validation to assess the fitness of the simulation for the specific application

Scenarios should be identified during problem definition and defined, refined, and verified as part of the M&S requirements. To ensure the scenarios are based on accurate and authoritative information, the User should enlist the support of SMEs to

[16] See the special topic on Requirements for additional information.
[17] See the special topic on Risk and Its Impact on VV&A for additional information.

script situations and define use cases to be used. Scenarios can be scripted from the perspective of the problem domain (e.g., describing how a weapon system to be modeled is employed) or the user domain (e.g., describing how the User would like to use the simulation).

Identify Measures of Success

After M&S requirements are defined, the User should work with the Accreditation Agent, V&V Agent, Developer, and M&S PM to determine how success for each requirement should be measured. This is accomplished by identifying appropriate measures (e.g., measures of effectiveness [MOEs], measures of performance [MOPs])[18] and establishing the acceptability criteria (e.g., standards for success, thresholds) for each requirement (see Appendix B for examples). The User and Accreditation Agent are the primary actors in establishing measures and acceptability criteria. However, participation by the Developer and V&V Agent is important – the Developer can provide criteria for the simulation domain and the V&V Agent can verify the accuracy and completeness of data, simulation performance, and behavioral representations for these criteria.

A precise relationship among program objectives, measures, criteria, and the resulting simulation outputs is essential. M&S requirements constitute a basic set of parameters from which a checklist of acceptability criteria can be developed to compare against simulation characteristics and capabilities. This comparison is an essential aspect of accreditation planning because it objectively justifies the selection of specific V&V and accreditation activities; however, additional information about the problem being addressed and the program being supported (e.g., how critical the program decisions are; how program decisions will be affected by simulation results) is needed to establish priorities and determine the magnitude of the V&V effort.

Select Legacy Simulation

Normally, the User decides to use a legacy simulation concurrent with or soon after selecting simulation as the method to use. This decision may dictate which simulation to use or it may simply define a range of credible candidates. The process by which legacy simulations are actually selected varies widely. In some cases the legacy simulation selected is predetermined; in other cases, the User may need to conduct a search[19] and compile a list of candidates.[20]

A specific simulation may become a candidate for a number of reasons:

- the simulation has a good reputation in the community

[18] See the special topic on Measures for additional information.
[19] Such a search might include surveys of recent simulation usage by other members of the user community and examination of on-line repositories of M&S information, such as the Modeling and Simulation Resource Repository (MSRR).
[20] Note that different versions of the same simulation may be considered different candidates.

- the User is familiar with it
- the simulation is available
- the User has access to the necessary hardware and software
- the simulation has a well-documented pedigree and record of usage
- the simulation's advertised capabilities appear to match those of the intended application

When there are several viable candidates to choose from, each candidate should be reviewed to determine if it appears to have the capabilities needed for the intended application. The focus of this review is on high-level concerns such as the availability and maintainability of the candidate, its reputed quality both in terms of the entities modeled and the documentation available, and the possibility and estimated cost of any modifications required to fit the specific application. The questions listed below identify some key factors to consider in this preliminary assessment.

Basic Questions to Establish Simulation Capability
• What information is needed to support the major decisions or to resolve key problem issues?
• What specific simulation outputs relate to the information required?
• How good do these outputs need to be? What is the level of tolerance for uncertainty in the outputs?
• How will simulation outputs be used to produce the needed information?

The capabilities of each candidate should be reviewed to determine if they can accommodate the M&S requirements of the intended application. One technique is to collect information about each candidate and compare its representational capabilities to the capabilities required by the intended application. This capability characterization is normally performed by the Accreditation Agent, assisted by the V&V Agent and/or the Developer.[21] Typical sources for the necessary information are provided in Appendix A.

Another technique for examining simulation capabilities is to execute an existing simulation using a very small sample of the M&S requirements. In addition to providing valuable information about the capabilities of the simulation at a minimal cost, this exercise will familiarize the User with the tool and help identify what representational capabilities need to be added or modified. It can also serve as an opportunity to refine the M&S requirements, tailoring them to better suit the available tools (e.g., revising the fidelity).

Additional factors to consider include:

[21] See the core documents on the Accreditation Agent, V&V Agent, and Supporting Roles in the VV&A of Legacy Simulations for additional information.

- **Costs and benefits.** The trade-off between the costs and benefits of using a specific simulation should be analyzed, even if they are only estimates.

> Example:
>
> A simulation with a well-documented pedigree seems to be an attractive selection when the pedigree is considered alone; however, the costs involved (e.g., costs of purchasing necessary hardware or software, modification costs, data costs, training costs) may far exceed the costs of discovering the capabilities of a different simulation that may need less modification.

The impacts of financial and schedule costs should be weighted appropriately. A User pressed for quick answers to critical questions may defer financial costs for reduced schedule. Both factors are likely to play some part in the selection but should have different weights in different situations.

- **Purpose of the intended application.** The User should consider the requirements of the intended application and the criticality of the decisions to be made using simulation results in order to determine how much flexibility to allow in the simulation. One simulation may enable the User to address 80% of the M&S requirements with no modification whereas another simulation may address 95% of the User's objectives but require a huge financial and schedule investment to add the needed capabilities. However, if the purpose of the application involves human safety (e.g., medical diagnostics, pilot training) then the risk factor may require that the 95% simulation be selected.
- **Simulation credibility.** Credibility is predicated on a User's belief in the fitness (capability, accuracy, correctness, and usability) of the simulation. In many cases, confidence in a given simulation is derived through personal experience or from the testimonials of the experiences of others. However, Users should be careful to ensure that the experiences being considered are relevant to the intended application. While this advice seems obvious, many subtleties lie in using simulated representations. For example, a credible simulation of nuclear effects may provide very poor information of the dispersion of contamination if it models the weather and terrain poorly.
- **Support infrastructure.** Initial support for a legacy simulation comes from the M&S Proponent of the simulation who serves as the primary source of simulation documentation and experience. Developers who participated in the simulation's development and enhance, if available, can also play an important role. Finally, the support from an existing user community can serve many purposes such as the source of capabilities, training, usage, and maintenance information. A broad user base and an active M&S Proponent with a good configuration management system can help to minimize execution and representation faults through an ongoing feedback and response process.

Analyze Risk and Uncertainty

In order to focus the V&V effort and accreditation assessment, it is necessary to first identify and estimate the risks associated with using the legacy simulation in the intended application (i.e., operational risk, inherited risk, modification [development] risk).[22] Risk assessment can be conducted to determine

- what risks would result from an incorrect decision based on simulation results
- what simulation limitations, weaknesses, incompatibilities should be considered show-stoppers
- what kinds of risks are involved (e.g., safety, financial, unit effectiveness, program jeopardy, etc.)
- who would be affected by the consequences of these risks and to what extent
- what visibility an incorrect decision would have
- what specific issues or concerns associated with the application should be considered as risks

An initial risk assessment should be performed by the User in connection the problem analysis or by the Accreditation Agent as part of establishing the scope of the accreditation assessment. Risk assessments can also be performed by the User and others (e.g., Accreditation Agent, V&V Agent) to address a variety of needs, such as

- identifying operational, inherited, or modification [development] risks
- establishing the scope of the accreditation process
- establishing priorities for the V&V effort
- determining what types of V&V information are necessary to support the accreditation assessment
- determining how to address simulation deficiencies

Risks should be reassessed whenever new information is available or changes have occurred that can affect the priorities. Risk assessments performed in conjunction with major events and activities throughout the legacy assessment and preparation process can have a major impact as shown in the table below:

Event (Activity)	Risk Assessment
Initial Assessment (*Determine Scope of Assessment*)	• identify and rank the information needed about the existing simulation
Simulation Capability Assessment (*Identify Critical Deficiencies*)	• identify and rank critical deficiencies in the simulation
Modification Planning (*Plan Modification*)	• determine how to address individual simulation deficiencies

[22] See the special topic on Risk and Its Impact on VV&A for additional information.

V&V Planning (*Develop V&V Plan*)	• identify and rank evidence to be collected about the simulation through testing and V&V
Accreditation Assessment (*Perform Accreditation Assessment*)	• determine the fitness of the simulation for the intended use

Designate Accreditation Agent

The optimum time for the User to designate the Accreditation Agent is when the decision is made to use a legacy simulation. This ensures the Accreditation Agent is available to provide technical support during early events and decisions, such as

- supporting M&S requirements definition [p. 10] by ensuring appropriate metrics and acceptability criteria are selected
- conducting or supporting the risk assessment, identifying accreditation information needs and establishing priorities for the V&V effort
- evaluating the available simulation information for sufficiency
- conducting the technical assessment comparing the simulation capabilities to the M&S requirements

The User should select an Accreditation Agent based on experience with the type of simulation involved and knowledge of the problem domain as well as experience in the field of accreditation assessment.

Designate M&S PM

The M&S PM is responsible for planning and managing the modification effort, where one is needed. In many instances, as when the modification is relatively straightforward, these functions are performed by the User and Developer, respectively. However, when the modification effort is very large or complex, the User will designate a separate M&S PM.

When the simulation version being modified is the version under program configuration control, the M&S Proponent may participate in the M&S PM selection. Then, the M&S PM, User, and M&S Proponent work together to determine when, and how the simulation will be modified.

Identify Authoritative Data Sources

Locating and preparing data to be used in a simulation can be costly in terms of both time and effort. Legacy simulations were developed to use specific categories of data in specific ways. Thus, it is important to locate data that satisfy the needs of the existing simulation as well as address the needs of the new application. Previously used data should be considered and new data needs should be identified as early as possible (e.g., during the initial assessment of simulation capability). Issues to be addressed include:

- Does sufficient information exist about what data sources were used, what data categories were involved, and how the data were structured and prepared?
- Are these data sources available?
- Are these data sources still appropriate?
- Are new data categories or types required?

The User and Developer, as part of the assessment of simulation capability and M&S requirements refinement, identify the data needs of the simulation. These may be the same as were previously used in the simulation or there may be some new data needs based on the M&S requirements for the intended application. The User identifies authoritative data sources (for both previously used data and new data) and the Developer generates any requests for data. The V&V Agent investigates the appropriateness of the data information and data sources and the Developer prepares the data for use.

Establish Overall Strategy

The User works with the Accreditation Agent (and V&V Agent, M&S PM, and Developer if available) to develop an overall strategy for preparing the simulation and conducting an effective VV&A effort. This effort should begin as soon as the decision is made to use legacy simulation and the Accreditation Agent and M&S PM are selected and should continue until the simulation assessment is made when it is used as the basis for planning. It involves conducting problem analysis [p. 10], identifying risks [p. 14], profiling the modification process (if any), scoping the overall effort, establishing priorities, defining the relationships between the various participants, identifying products and documents to be produced, and establishing milestones.

Designate SMEs

The User is relied upon to identify subject matter experts (SMEs)[23] in the problem and user domains to participate in the simulation preparation, V&V activities, and the accreditation assessment. Such expertise is particularly critical to the V&V effort, where SMEs are needed to support requirements verification, conceptual model validation, results validation, and other areas where their domain expertise can contribute to the accreditation decision. Problem and user domain SMEs are also important during the definition and refinement of M&S requirements and the modification of the conceptual model.

SMEs normally require some level of resources. Government employees (e.g., military experts) usually require travel costs at a minimum; experts from the private sector generally require compensation for their time as well. The User should verify that funding for SMEs is included in the budget.

[23] See the special topic on Subject Matter Experts and VV&A for additional information.

Primary User VV&A Support Activities

The primary User VV&A support activities include:

- Determine Sufficiency of Available Information [p. 18]
- Assess Simulation Fitness [p. 21]
- Identify Critical Deficiencies and Plan Modification [p. 23]
- Make Accreditation Decision [p. 26]

The User's primary concern is whether the simulation will produce credible results when applied to the current problem. The VV&A effort focuses on finding the information that can demonstrate the simulation's fitness for this purpose. The accreditation assessment can be viewed as the driver of the entire legacy simulation preparation effort. As discussed in the *Legacy Simulation Overview* and shown in the flow diagram [p. 4], the Accreditation Agent defines the scope of the assessment in terms of risks, priorities, and what information is needed to satisfy the User's concerns. The V&V efforts are then planned to provide this information. The entire simulation preparation effort (e.g., modification, V&V, testing) is focused on ensuring that the simulation satisfies the intended application's requirements with as little risk as possible based on the priorities established.

Legacy simulation assessment involves two different assessments.

- ***Determine sufficiency of available information*** assesses the available information and determines if more is needed in order to make a decision about the simulation
- ***Assess simulation fitness*** evaluates the simulation's fitness for the specified purpose.

If the latter assessment shows that the simulation is fit to use without modification ("as-is"), then the simulation can be prepared for use and the User can issue the accreditation decision. If instead it indicates that modifications are needed, then an additional assessment is needed to evaluate the fitness of the simulation following modification.

Determine Sufficiency of Available Information

During this assessment, two basic questions are asked:

- *Is sufficient information available to assess the legacy simulation?* [p. 19]
- *Are the M&S requirements adequately defined?* [p. 20]

When both of these questions can be answered affirmatively, the process can continue with the assessment of the simulation's fitness [p. 21].

Is sufficient information available to assess the legacy simulation?

This effort is normally led by the Accreditation Agent. All available documentation about the legacy simulation is collected and reviewed to determine if it is adequate to assess the simulation's capabilities, limitations, and usability for the intended purpose, such as:

- technical documentation, artifacts, and products (e.g., M&S requirements, simulation conceptual model, design, code) resulting from simulation development and/or modification
- reports and records of the simulation's prior usage (e.g., study reports, simulation handbooks and user manuals)
- simulation configuration management documentation
- simulation VV&A history

Typical documentation sources include the simulation's M&S Proponent, previous Developer(s), and previous Users. If necessary information about the simulation's existing capabilities is missing or incomplete, then the User may call upon the Developer or V&V Agent to provide it. In the simplest case, missing information can be pieced together from available artifacts and documentation (e.g., requirements can be retraced through the existing artifacts; a surrogate conceptual model can be pulled together from design documents and requirements specifications). In other cases, one or more of the methods listed in the table below can be used to generate the necessary information.

Methods for Obtaining Additional Information
• Review V&V history
• Interview previous Developer(s)
• Conduct tests
• Conduct regression analysis
• Interview previous Users
• Perform reverse engineering
• Perform supplemental V&V

The methods chosen and the amount of effort expended are influenced by

- what has been done before
- what information is missing
- the importance of the missing information to the problem being addressed
- the criticality of the simulation's results
- the availability of time and resources

Example:

A subcontractor remodeling a bathroom may not need to see any blueprints of the house unless plumbing lines, electrical lines, or heating ducts are going to be moved because there is little risk of complications.

A subcontractor converting part of an attached garage into a bathroom would want to see some, but not necessarily all, of the blueprints associated with the house. Blueprints showing the electrical wiring, plumbing, and ductwork of the garage and adjacent rooms are needed to determine where windows and doors can be added and how best to extend the heating ducts, wiring, and plumbing, etc.

When resources and time are both limited, the effort to obtain information should be confined to areas of the simulation (identified during the risk analysis [p. 14]) that are most critical to the User's problem.

Newly generated information and information obtained from secondary sources (e.g., interviews, unofficial documentation) should be verified for consistency with previously available information. The User supports this activity primarily by providing the resources needed for its completion. Additional information on information sources is provided in Appendix A.

Are the M&S requirements adequately defined?

Requirements refinement should be led by the User, who can provide first-hand information about the intended application. The effort should be supported by the Accreditation Agent and Developer, who can help determine the degree of refinement (i.e., level of detail) required.

Requirements are verified to ensure that they are clearly articulated, consistent, and complete. The V&V Agent normally conducts requirements verification with support from the User, who provides expertise on the application and on the accuracy, completeness, and currency of the requirements definitions. The User also reviews and approves technical progress and status reports, and serves as the final decision maker on resolving any inconsistencies.

Major considerations to ensure requirements are sufficiently refined and verified include:

Major M&S Requirement Considerations
The M&S Requirements should fully describe the solution.
• The M&S requirements [p. 10] come from three domains: problem (i.e., details of the specific problem being addressed), user (i.e., the specific subject area or field of use of the application), and simulation (i.e., capabilities and characteristics of the simulation itself). All three domains are needed to fully characterize the functionalities, representations, conditions, and constraints needed in the simulation to obtain satisfactory results.
Requirements should be measurable.

Major M&S Requirement Considerations
• Measures [p. 12] should derive logically from the defined requirements.
Requirements should have specific criteria that define success.
• Acceptability criteria [p. 12] describe how the simulation should perform when completed. They define how the User determines that the simulation is sufficient for the application. Acceptability criteria should be developed initially in concert with M&S requirements definition and refinement and then should be developed fully as part of the simulation conceptual model.
Requirements should be traceable.
• Each requirement and associated components (e.g., definitions, measure, acceptability criteria) should be traceable to an objective, as elucidated in the problem statement. Likewise, the each requirement should be traceable to one or more components of the implemented solution.

Credibility should be the key driver in determining the acceptability of the simulation for the application. The User's belief that the simulation is credible depends on how much risk the User is willing to accept. This question is often difficult to answer because the User seldom specifies risk in concrete, quantifiable terms. However, a rigorous risk assessment can help answer this question.

Assess Simulation Fitness

Once there is sufficient information about both the simulation and the M&S requirements, the simulation's existing capabilities can be compared to the M&S requirements of the intended application to determine what has to be done, if anything, to ensure the simulation can meet all the needs of the application. Some basic questions to be addressed are shown in the table below.

Basic Questions to Establish Simulation Fitness
• Does the existing simulation represent all of the objects, properties, and dependencies required for the intended application?
• Does the existing simulation represent any objects, properties, or dependencies that will conflict with the needs of the intended application?
• Does the existing simulation represent the desired objects, properties, and dependencies with the fidelity required for the intended application?
• Is the simulation's input data structure (i.e., The organization of the various categories of input data used) adequate for the intended application? Do new input data structures need to be devised to address new data needs?
• Are the input data elements used in the existing simulation acceptable for the intended application? Do new input data elements need to be added to the input data structure?
• Are the output data obtained from the existing simulation sufficient to address the output needs of the intended application?
• Does the existing simulation's VV&A history indicate that verification efforts have adequately demonstrated the correctness of the simulation in the areas of concern for the intended application?

Basic Questions to Establish Simulation Fitness
• Does the existing simulation's VV&A history indicate that validation efforts have adequately demonstrated the accuracy of the simulation in the areas of concern for the intended application?
• Were the V&V efforts conducted against looser tolerances than those required by the intended application?
• Does the accreditation assessment present results and findings that the intended User can accept as credible?
• What is the existing simulation's use history? Is there a current user group? Is the simulation under configuration management? If so, by what group?
• Is the user information (e.g., programmer manuals, user guides, tutorials, input database structures) sufficient for the current User's needs? Are the tools, hardware, etc. needed to run the simulation available and in working order?
• What are the inherited risks?[24]

This assessment is conducted by the Accreditation Agent as part of the accreditation process. The Accreditation Agent presents the results to the User, including evidence obtained from any testing and V&V activities conducted (e.g., software verification, data V&V, results validation), the rationale for the conclusions reached, and recommendations about the simulation's fitness for the intended use. The User reviews the results and recommendations and determines if the simulation can be used as is, needs modification, or should not be used at all.

- **Reject simulation**. When the results of the assessment indicate that the simulation would require extensive modification, the User must determine if there are sufficient time and resources available and whether the results of the modified simulation would provide sufficient credibility.[25] When the costs (in resources, time or credibility) are too high and the User decides not to use the simulation, the decision is made to either select a different simulation or to select a different method to solve the current problem.
- **Use simulation as-is**. If the assessment indicates that the simulation possesses the necessary capabilities to address the M&S requirements and there is sufficient evidence to demonstrate the simulation's correctness and accuracy, then the risk of using the existing simulation is relatively low. When the User decides to use a simulation as-is, preparing the simulation for use consists of obtaining and preparing the input data and testing the simulation for use in the intended application. The V&V effort consists of assessing the capabilities and correctness of the simulation based on existing simulation information and conducting data V&V and results validation to assess the

[24] Inherited risks are risks associated with using a simulation over which there is no developmental control. The User of a legacy simulation cannot impact the simulation's development and essentially has to live with any risks due to the design, hardware, programming techniques, languages, etc. that were chosen during development.

[25] The reputation attained by the existing simulation may be undermined by extensive modifications. Trust in the reliability of the modified simulation will have to be built on the testing and V&V efforts conducted.

accuracy of the representations in the intended application. When the evidence demonstrating the simulation's correctness and accuracy is not sufficient, then the V&V effort should include supplemental V&V tasks to obtain the necessary information.

- **Modify the simulation**. When the assessment indicates that some modification is needed, the User evaluates the availability of time and resources to make the changes and the risks involved. When the decision is made to modify, the following modification activities are initiated.

Identify Critical Deficiencies and Plan the Modification

Identify Deficiencies

Although the Developer, V&V Agent, and other technical SMEs are usually responsible for identifying the deficiencies, the User is heavily involved as the decision maker. Simulation deficiencies and limitations are identified during an assessment of the simulation capabilities in which the capabilities of the legacy simulation are compared to the simulation capabilities needed to address the M&S requirements.[26] As deficiencies are identified, decisions have to be made regarding how they should be addressed. The User's role typically involves

- providing guidance for prioritizing deficiencies
- balancing the risks associated with the various approaches for addressing deficiencies (noting that there are risks associated with modifying code that may be greater than the risk of not correcting a deficiency)
- identifying the resources available.

Not every deficiency can or should be addressed by modifying the simulation code. Some deficiencies may be addressed by work-arounds, such as setting limitations on the simulation use, changing input data, or complementing the main simulation with other simulations.

- When deficiencies are small and localized, minor modifications may be relatively easy to implement (e.g. changing the boundary conditions of a search algorithm). However, the User may elect to employ work-arounds (e.g., using different data, changing the scenarios), or do nothing. The Developer carries out the modifications, changes, and work-arounds as directed, documents each deficiency and its solution, updates development artifacts, prepares the data, and tests the modified areas. The V&V Agent tests the effectiveness of the work-arounds, verifies modified code, and performs data V&V and results

[26] Although the Developer is normally responsible for identifying deficiencies, this assessment may be led by the Accreditation Agent.

validation. The Accreditation Agent assesses the risk associated with each deficiency solution. .

- When significant deficiencies are found and code modification is necessary, then the modification effort should follow a process similar to that of a new development, with the modification being planned and executed in phases, and development artifacts updated. V&V activities are coordinated with each of the modification phases and the modified areas of the simulation are evaluated for their correctness and their impact on the performance of the overall simulation.

A list should be made of all deficiencies identified, how they are to be addressed, and why. This ***deficiency list*** is then used as the basis for the modification plan.

Plan Modification

The modification plan is usually developed by the User or the M&S PM with support from the Developer and in coordination with the V&V Agent and Accreditation Agent. The plan should account for and prioritize every deficiency identified and describe how it will be addressed. When the version of the simulation to be modified is the one under program configuration control, the plan will need to be approved by the M&S Proponent. Once approved, the Developer implements the list of modifications in priority order.

The prioritized deficiency list should be used to develop the V&V and accreditation plans. Essential planning information should be collected and filtered and used to shape the V&V process and accreditation assessment. The User, as the spokesperson for the problem and user domains, can provide much of this information. The table below shows some of the materials gathered during this activity:

Typical Simulation Planning Information
• Warfighting roles, missions, and operational objectives
• Environment, geography, engagement locations, terrain, ocean, space, etc.
• Scenario-driven and general operational capabilities
• Specifications and requirements on the system(s) being modeled
• Schedule for planned use (required accreditation date)
• Resources required (including participants)
• Modification schedule, including conceptual modeling, design modification, implementation, and testing
• Known uncertainties and risks
• Miscellaneous planning information
• History of previous use and V&V and accreditation results.

The scope and character of both the accreditation and V&V efforts take shape as these resources are reviewed and analyzed. This collection of information serves as the basis for formal accreditation and V&V planning as shown in the table below:

Typical Accreditation Planning Information
• Schedule
• Number and location of sites involved
• Requirements of the application
• Generalized scenario and operational constraints
• Acceptability criteria
• Risk and uncertainty factors
• Information provided by V&V activities
• Additional assessment activities
Typical V&V Planning Information
• Schedule
• Number and location of sites involved
• Requirements of the simulation use
• Generalized scenario and operational constraints
• Acceptability criteria
• V&V event scheduling within the modification and test program
• Risk and uncertainty factors
• Information to gather for accreditation assessment

Tailoring is an attempt to provide the most appropriate analysis possible within the constraints of time, resources, and cost. It involves the development of a balanced (i.e., neither excessive nor insufficient) V&V approach by determining the verification and validation tasks needed to determine credibility and then by adjusting the level of effort based on resources available. Normally, there are gaps between what is desired and what is sufficient and what is possible (i.e., what is affordable) and tradeoffs have to be made. A tailored approach uses the information obtained during risk analysis to identify high-risk areas on which to focus the effort. The User should describe the relative importance of each requirement to ensure the V&V effort can provide the most effective evidence within the funding available.

Cost-effective accreditation balances the need for simulation credibility against real-world schedule and budget constraints. The V&V effort, in support of accreditation, should be balanced in the same way that other facets of the simulation preparation are balanced to achieve an overall better, quicker, cheaper product. Careful tailoring of the V&V process can produce an audit trail of well-defined program objectives and decisions. This information can help the User better understand limitations, constraints, and risks involved in using the simulation.

Make Accreditation Decision

Once the modification, testing, and V&V activities have been completed, the Accreditation Agent evaluates the overall fitness of the modified simulation for the intended use by examining the evidence collected, assessing the risks associated with the decisions made and assessing the effectiveness of the changes made, and submits the Accreditation Report to the User.

The User's accreditation decision [p. 5] is a key point in the problem solving process. It is "the official determination that a model or simulation is acceptable for a specific purpose." During the simulation development or modification, the User provides focus and redirection to accommodate changing requirements.

The User's accreditation decision is based on the Accreditation Report. This report should include results and recommendations about the risks associated with using the simulation as intended, constraints and limitations, and permissible ranges of use for the simulation. The User should review the report and verify that the assessment includes the following:

- evidence that requirements and acceptability criteria were clearly defined and that the legacy simulation capabilities were evaluated against them
- evidence that the assessment included a review of simulation capability, operator capabilities, simulation and user documentation, equipment compatibility, data collection, and data credibility
- identification of each deficiency and an explanation of how it was addressed, including the constraints, limitations, and risks involved

If the evidence indicates the simulation meets the acceptability criteria and the User concurs with the results and findings, the accreditation decision should follow easily. However, when the evidence shows that simulation performance falls short of the needs of the application, then the User must choose between

- taking more of the available time and resources to correct the problems (e.g., modify the simulation or change simulations)
- accrediting the simulation for full use (i.e., accepting the high risks associated with using the simulation without further correction)
- limiting the accreditation (i.e., executing or accepting results only from those portions of the simulation that are low risk).

If the User elects to allow limited accreditation, then the constraints and limitations should be clearly identified and ranges of permissible usage should be clearly defined.

Secondary User VV&A Support Activities

The foregoing discussion focused on the activities and tasks in which the User plays a major role. However, the User should be involved in every activity in the overall

problem solving process. The following discussion identifies some additional tasks in which User involvement in the background is important. The Secondary User VV&A Support Activities discussed include:

Support Simulation Conceptual Model Modification and Validation

The simulation conceptual model[27] serves as an excellent source of information about the existing simulation and should be updated to reflect all modifications and changes (e.g., scenarios, data) involved in the intended application. User participation in the modification and validation of the conceptual model is extremely important. The User participates by articulating the appropriate level of abstraction of the real world (simuland) needed for the intended application and by providing scenarios, use cases, limitations, and constraints imposed by the intended application. The User also should review revisions to the simulation conceptual model to ensure that they adequately address the current requirements.

Support Data V&V

All data used in the simulation, regardless of whether they were previously used in the simulation or new and regardless of whether they are input or hard-wired,[28] should undergo data V&V[29] to ensure they are appropriate for the intended application.

> Example:
>
> - Sources for previously used data may not be authoritative sources for the current User
> - Hard-wired data values may need adjustment because of changes in the required fidelity.

The extent of the data V&V effort also depends on the amount of new data involved and the similarity between the intended application and previous applications. Although the data V&V effort is handled primarily by the V&V Agent and Developer, the User should participate in planning the effort to ensure appropriate resources are allocated.

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[27] See the special topic on Conceptual Model Development and Validation for additional information.
[28] See the reference document on M&S Data Concepts and Terms for additional information.
[29] See the special topic on Data V&V for Legacy Simulations for additional information.

Support Validation

Although the V&V Agent conducts the validation effort and assembles the validation documentation, based on guidance provided by the Accreditation Agent, the User should also be intimately involved with the review and approval of validation methodology and results. The User supports the validation effort by prioritizing the requirements to be addressed and identifying the output data to be collected.

Frequently, there are no validation data (e.g., empirical data, test results) available for comparison with simulation results. If this is the case, SMEs from appropriate functional areas should be consulted for their "view of the real world" based on the scenario [p. 11] and use cases involved. The baseline they provide is used for the comparison.

Validation tests, developed by the V&V Agent with support from the User and other SMEs, should be capable of exercising the needed simulation capabilities. Validation tests should be run against the planned scenario(s) to obtain representative results.

Verify User Documentation

Because good instructional and user manuals are needed to execute and operate a simulation, the User should be critically interested in their completeness, appropriateness, utility, and currency. The manuals should be reviewed and verified to ensure they are complete, accurate, consistent, and serviceable since their use has a direct impact on the User's ability to operate the simulation. As the ultimate user on how the simulation should be employed, the User would typically be the one of the SMEs involved in this review.

VV&A Challenges of the User Role

The User faces a number of challenges in establishing the accreditation effort and making the accreditation decision including:

Matching the Legacy Simulation to the Problem

Possibly the User's biggest challenge is making sure the legacy simulation is fit to address the current problem. If the User has a number of legacy simulations to choose from, the first challenge is to select the best one for the job. Simulation capability, limitations, previous history, usability, and availability need to be considered for each

candidate. If the legacy simulation is predetermined, then the User still must ensure it is adequately understood so its preparation will result in a simulation fit for the intended application.

In addition, how the simulation will be used in the intended application has to be well understood so the risks involved can be identified and appropriate efforts made to mitigate them. This is particularly important when using a legacy simulation because the User is starting with a simulation that was developed for a different purpose, however similar it is to the intended application.

> Example:
>
> Simulations that are developed for multiple users often have broader capabilities than would normally be needed for one particular application. For example, one semi-automated forces (SAF) simulation was developed to accommodate both Army training and analysis applications. A User with an analytic application would be more concerned about the simulation's repeatability than a User with a training application.
>
> A simulation designed for force on force analysis may not have the movement algorithms, attrition algorithms, environmental representations, etc. to be used in a ground mine study involving the same forces in the same scenarios.

Identifying the differences between the simulation capabilities that are needed to address the current problem and the capabilities the existing simulation already has should be done early so an appropriate simulation preparation process can be implemented.

> Example:
>
> A virtual simulation that was highly successful as a training tool was selected as an analysis tool. After a year of use, the program had no significant results because the simulation provided only qualitative anecdotal information instead of the quantitative information needed for analysis. The requirement for quantitative results had not been stipulated when the simulation was selected for use.

Measuring Success

In order to establish the fitness of the simulation for use in the intended application, the User and Accreditation Agent need to identify ways to measure the simulation's ability to address the M&S requirements[30] (e.g., performance, effectiveness, etc.). These measurements should be accomplished in terms that can be compared to a set of pre-determined criteria that identify what level of capability is needed to be acceptable for the intended application. Conducting a formal problem analysis can help the User ensure the problem is sufficiently defined and the M&S requirements are consistent.

[30] See the special topic on Requirements for additional information.

Once the M&S requirements have been identified and appropriate fidelity[31] and measures[32] have been determined for each, the User and Accreditation Agent need to establish the level of success needed for each, i.e., the level the simulation needs to meet in order to be acceptable (i.e., acceptability criteria).

Example:

A training application represents tasks required to locate, identify, and engage a target with the *abcxyz* weapon system. The simulation needs to represent communications with higher, lower, and adjacent weapon systems and all other battlespace entities and needs to provide the primary human-systems interfaces and the situational awareness output.

Fidelity:

- represent the readouts, buttons, and other physical objects a shooter must use to acquire a target
- represent the readouts, buttons, and other physical objects a shooter must use to fire at and evaluate battle damage of a target

Measures:

- time required to identify a target within X percent of actual time observed in real-world tests
- accuracy rates of target identification within X percent of real-world tests
- time required to acquire and engage a target within *X*-percent of real-world tests

Acceptability Criteria:

- simulation must represent the logical and physical mechanisms (e.g., sight pictures, range-finding, and visual target representations) needed to evaluate whether the target is in range
- simulation should represent the physical mechanisms needed to acquire and fire at a target

The User ensures that the M&S requirements are sufficiently detailed and equipped with appropriate corresponding metrics and acceptability criteria. The quality of these criteria depends directly on the precision and completeness of inputs from the User. Examples of acceptability criteria are provided in Appendix B.

Obtaining Data

Obtaining valid data[33] to use in a simulation can be extremely time-consuming and costly. The original simulation was designed to use specific categories of data prepared in specific ways. Any reuse of the simulation requires understanding both what data were used and how they were prepared and applied in order to ensure the data

[31] See the special topic on Fidelity for additional information.
[32] See the special topic on Measures for additional information.
[33] See the reference document on M&S Data Concepts and Terms for additional information.

selected for the intended application can be used in the simulation. A simulation cannot simply be initialized and executed by blindly re-using the previously used data. Even when the existing data categories and structures can be reused, different data values are normally needed to address the specific needs of the intended application. Different data values may be needed because of the introduction of a new version of a weapon system or munition, or changes in the scenario, force structure, threat, or environment. Even when the same data can be used, they should be officially requested and obtained from the authoritative sources to ensure they provide the most current and accurate values.

> Example:
>
> Because of time constraints, an analysis of alternatives (AoA) study using an in-house legacy simulation elected to save time by establishing the base case by reusing the data set from a similar AoA study completed the previous year. However, when the new data arrived, the base case was shown to be invalid because of significant changes in the threat tank survivability and lethality data values. The previous values reflected a lack of training and support available to a threat force with newly acquired tanks. The revised threat tank values reflected the increased threat capability due to reorganization of the tank units and increases in training and support.

Information defining the data (metadata), identifying the data sources, describing the database structures used to house the data, and defining the transformations needed to prepare them for use, as well as their data V&V histories, should be part of the original documentation (e.g., programmer manuals, user guides, simulation conceptual model, detailed design).[34] This information is needed to ensure that the data chosen for use can be used in the simulation. If these data are not available, then they will have to be created.

By reviewing the sources and metadata of previously used data as early as possible, the User can determine if they are appropriate for the application. Although new data values will need to be obtained, it is preferable if the same data sources, structures, and data preparation techniques can be used.

> Example:
>
> The intended application requires a Middle Eastern scenario. Previous uses of the simulation have used Southwest Asian and European scenarios. Because the categories of data involved in each scenario are the same, the data structures and preparation techniques can be reused with minor adjustments.

If the intended application requires different categories of data then new data structures may need to be developed and new preparation techniques devised. Different categories of data may be required when

[34] See the RPG Templates on Data Quality for additional information.

- the simulation needs to represent new objects or behaviors to address the needs of the intended application
- algorithms that formerly used the data have been replaced by algorithms that require different data (e.g., converting from a nearest-square line-of-sight (LOS) algorithm to an interpolative solid surface LOS algorithm)
- the intended application requires a different level of security than the original

> Example:
>
> An Army training simulation has been selected for use in a joint training exercise. The training simulation was originally developed to operate in a classified environment and used Secret level data. The joint training exercise has to be Unclassified. All Classified data have to be replaced by Unclassified counterparts. Although the data structures can probably be reused, different data preparation techniques may be required to ensure the data can be used in the simulation. Because data ranges and boundary conditions are expected to be different for Unclassified data as opposed to their Secret counterparts, an extensive data V&V effort may be needed to ensure the simulation continues to operate properly.

Additional Challenges

Additional challenges include:

- **obtaining reliable and complete information about the simulation** – including development artifacts (e.g., requirements specifications, simulation conceptual model, design, code), user reports, VV&A history, etc.
- **tailoring** – finding cost-effective ways to assess the simulation; ensuring V&V activities are appropriate and adequate to meet the needs of the application.
- **avoiding de facto accreditation** – accepting the simulation without any assessment of its acceptability based on non-rigorous estimates of its worth.
- **assessing the appropriateness of V&V history** – ensuring the results of previous V&V efforts actually provided useable information about the ability of the simulation to meet the current need.

User's Relationship with Other Roles

Information Exchanges

The User is the authority on the application and serves as the final decision maker on all issues that impact the application (use). As such, the User is responsible for providing information shown in the table below to all participants:

User Provided Information
• Problem domain requirements
• User domain requirements
• Authoritative data sources
• SMEs
• Planned scenarios and use cases
• General information about the simulation usage including locations, facilities, organizations, etc.
• Other critical usage needs which may drive accreditation criteria

Re-use of a legacy simulation may not require that the following roles actually be accomplished by separate "individuals" (e.g., when the legacy simulation can be used as-is). The User or User organization may perform all the roles described below. Regardless of who performs a specific role, there is a flow of information between functions and a set of responsibilities for actions and decisions that need to be understood.

Example:

A User who is also responsible for modifying the simulation has two sets of functions to perform, each of which has a particular perspective. The User as *User* needs to remain focused on what the simulation capabilities need to be for the intended application; the User as *Developer* needs to understand what the simulation capabilities currently are. If the difference between the roles is not well understood, then there may be a problem with trying to fit the application to the simulation instead of the other way around.

To understand what the simulation needs to be able to do, the User needs a full description of the simulation's existing capabilities, limitations, and evidence of simulation accuracy and usability. To understand what the simulation needs to provide for the intended application, they also need extensive information about

- risks associated with using this simulation for the intended purpose
- data -- input data previously used in the simulation, input data being introduced for the intended application, and output data requirements of the intended application
- operators and analysts so that the assessment can evaluate the adequacy of the supporting documentation (e.g., user manuals, tutorials) that is available with the simulation

The table below summarizes the information exchanges between roles in the legacy simulation preparation process.

Information Exchanges between Roles						
Information	**User**	**VV**	**AA**	**PM**	**Dev**	**Prop**
Existing simulation	R	R	R	R	R	P
Existing simulation documentation	R	R	R	R	R	P
Requirements	P	R	R	R	R	
Accreditation decision	P					
Plans	P	R	R	R	R	
Modification Plans	A	R	R	P	R	A*
Funding / Schedule	A	R	R	P	R	
Simulation conceptual model		R		A	P	R*
Design(s)		R		A	P	R*
Code		R		A	P	R*
Implementation		R		A	P	R*
Manuals		R		A	P	
Test plans and results		R		A	P	
V&V plans	R	P	A	R	R	
Verification results		P	A	R	R	R*
Validation results		P	A	R	R	R*
Accreditation plans	A	R	P	R	R	
Acceptability criteria	A	R	P	R	R	
Accreditation information needs		R	P	A	R	
Accreditation reports	A		P			
When version of simulation involved is under program configuration control.						
P: Produces the artifact or product						
A: Approves or authorizes distribution of the artifact or product						
R: Receives or uses the artifact or product						

User's Relationship with the M&S Proponent

The M&S Proponent role is unique because it is responsible to the simulation program which may or may not be directly concerned with the version of the simulation being used in the intended application. Some simulation programs allow only one version of the simulation to exist; other programs maintain one authoritative version but allow other versions to exist. The relationship between M&S Proponent and User, or indeed, the extent of M&S Proponent involvement with the intended use of the simulation, depends on whether the version being used is being maintained under program configuration control.

- If it is being maintained under program configuration control, then the M&S Proponent will provide guidance on what artifacts will need to be provided back

to the program and what forms they should assume and have final say regarding any modifications.

- If the simulation is under strict configuration control, then the M&S Proponent may also determine when and by whom the modification will be made. In this situation, the cost of the modification may be borne all or in part by the simulation program.
- If the User is provided with a copy of the simulation not held under configuration control, then the User determines what modifications to make and provides resources and funding for the modification effort. The M&S Proponent's involvement is limited to providing information about the authoritative version of the simulation.

User's Relationship with the M&S PM and Developer

The roles of M&S PM and Developer come into play only when modification is involved, to manage and perform the modification, respectively. In many situations, the M&S PM role may be performed by the User. In some situations, when the modification is straightforward, the User may also act as the Developer. When a separate M&S PM and Developer are designated, they rely on the User to define the problem and provide requirements, locate authoritative data sources and SMEs, provide acceptability criteria, serve as a domain expert for the user and problem domains, and make decisions regarding potential changes to the modification schedule. The User should work closely with the M&S PM and Developer to ensure requirements are faithfully traced through the simulation conceptual model to the design and finally into code.

As the role responsible for managing the modification effort, the M&S PM should provide the User with frequent updates on the status of the modification effort and the V&V effort, support the User in resolving issues, and ensure both the modification and V&V effort remain on track. The Developer modifies the code, prepares input data for use, and supports the V&V and testing efforts. The Developer can also perform a number of verification tasks as part of the software development.

> Example:
> A well-designed software development effort can include a built-in code verifier that can provide a significant amount of information for implementation verification.

In most instances, the V&V Agent works closely with the Developer to obtain information; however, under some circumstances (e.g., low budget, uncomplicated modification to an existing simulation) the Developer may conduct the entire V&V effort.[35] The User and M&S PM should carefully evaluate the needs of the application and the Developer's ability to conduct V&V analysis before agreeing to this approach.

[35] The main danger in having the Developer responsible for the entire V&V effort is difficulty in maintaining independent viewpoints. A Developer's primary concern is to ensure the code does what it is supposed

When modifying a legacy simulation for reuse, there may be advantages to involving the "original" simulation developer in the modification. This is particularly true if the historical information for the legacy simulation is not available or incomplete. The original developer would have access to

- technical experts who designed and coded the simulation and have knowledge of the assumptions and trade-offs that were made
- details about the modification itself, tests and analysis performed, verification activities, results, and recommendations
- development tools, documentation libraries (including configuration management information), software libraries, and the code itself

Using the same tools and experts can be particularly helpful when evaluating the impact of the modified code on the remaining simulation. In addition, the original tests and analyses may supply additional information to support the final accreditation decision.

User's Relationship with the V&V Agent

The V&V Agent relies on the User to provide expertise regarding the problem domain requirements and the intended application, and to resolve issues arising during the V&V process. The User relies on the V&V Agent to provide evidence of the simulation's validity. The V&V Agent should provide timely reports and recommendations concerning problems throughout the modification process.

Although the V&V effort is conducted to support the User, the V&V Agent normally works directly with the Accreditation Agent. However, the User should participate in V&V information exchange meetings to keep the V&V effort focused on the needs of the application. By remaining involved in the V&V effort, the User can ensure that little problems don't develop into big ones and that errors, problems, and oversights are found early enough to prevent them from becoming showstoppers. The User may want to develop a tracking mechanism to ensure continuity of information received from the various agents.

User's Relationship with the Accreditation Agent

The Accreditation Agent works directly for the User. They should work closely together to ensure the scope and timing of the accreditation process will result in an appropriate accreditation decision.

The User relies on the Accreditation Agent to

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to; the V&V effort is expected to go beyond this and evaluate if the simulation provides results that are sufficiently credible to be used in the application.

- conduct or support the risk assessment
- develop or support development of acceptability criteria based on the requirements of the application and acceptable risk
- identify the information needed for the accreditation assessment
- establish priorities for the V&V effort based on the accreditation information needs
- provide resource and cost estimates for the conduct of the accreditation effort
- plan and conduct the accreditation assessment
- produce the accreditation assessment report

As the one responsible for making the accreditation decision, the User designates the Accreditation Agent, coordinates the funding for the accreditation effort, and ensures the program develops the information needed for the accreditation assessment. The User and Accreditation Agent should work together to develop appropriate acceptability criteria and establish priorities for the V&V effort. The User should provide subject matter expertise and information regarding the problem and user domain requirements as needed throughout the accreditation assessment process.

User's Relationship with Others

The User's interest in the accreditation of the simulation can result in relationships with additional organizations and agencies that can provide important information for the accreditation decision.

Test and Evaluation

To leverage efforts that can provide additional accreditation information and reduce costs, the User should encourage cooperation and collaboration between the V&V effort and Test and Evaluation (T&E)[36] and other analytic efforts involved with the simulation or the application. Combining tests, sharing data, and comparing results can help reduce overall cost and improve the comprehensiveness of the information collected. Involving outside organizations in reviews and spot testing can provide additional evidence regarding the fitness and credibility of the simulation.

Subject Matter Experts

Subject matter experts (SMEs)[37] are relied on throughout the modification and use processes to help with requirements definition, simulation conceptual model design, scenario development, and to provide information on a variety of topics (e.g., operational doctrine, tactics, and procedures; software languages; data; physical and

[36] See the reference document on T&E and V&V Integration for additional information.
[37] See the special topic on Subject Matter Experts and VV&A for additional information.

natural laws and relationships; hardware). SMEs are also involved in the V&V and accreditation efforts to perform various tasks, such as providing "real world" data for validation testing and participating in face validation efforts during simulation conceptual model validation and results validation. The User normally would identify SMEs with expertise in the problem and user domain.

Documentation Requirements

Complete and accurate information about those aspects of the existing simulation that pertain to the intended application is essential for the accreditation effort. If the existing simulation has been under configuration control, much of this information should be available through the M&S Proponent in the simulation documents and artifacts. Other information may need to be obtained from previous Users or Developers.

Information about the Existing Simulation
• problem definition and objectives
• M&S requirement definitions, measures, and acceptability criteria
• M&S requirements tracing matrix
• validated annotated simulation conceptual model
• sources of real world knowledge and data
• verified annotated simulation designs (preliminary and detailed), including design entities (e.g., objects, attributes, parameters)
• design entities mapping to simulation conceptual model elements, objectives, requirements
• verified code
• testing reports (including techniques, data, scenarios (use cases), and results)
• data generation flow analysis, data producer quality assurance (QA) reports, and data V&V reports
• VV&A history
• V&V reports (including techniques, data, scenarios (use cases), problems identified and their resolution, and results)
• accreditation report (including accreditation information needs, assessment report, modifications/revisions required and accomplished, constraints, limitations, assumptions associated with the application)
• user documentation (including programming manuals, user guides, data storage and preparation reports)
• usage history (including study reports, after action reviews, training scenarios, results of execution, etc.)

If the existing simulation was not under configuration control or if necessary information is unavailable or suspect (e.g., incomplete, inconsistent, obtained from non-controlled sources), it may need to be recreated by generating the missing documents or artifacts,

reengineering the code, or regression testing. The scope of this effort depends on what information is missing and how critical it is to the intended application.

The information collected during the VV&A effort (see Appendix C) should be archived so future users of the legacy simulation can benefit. It is costly and time-consuming to re-generate VV&A information, particularly when it involves repeating tests and other V&V activities.[38]

Documentation should be approached realistically. Documentation should be planned in collaboration with all participants and should follow the form and format specifications established for configuration control. Careful planning can result in products that serve both current and future Users, Developers, V&V Agents, and Accreditation Agents.

Simulation Artifacts

If the simulation is to be modified, the Developer should generate documentation and artifacts describing the modifications (e.g., modified requirements specification, modified simulation conceptual model, modified design). These documents and artifacts are important sources of information for the V&V effort and the accreditation assessment. They also are important additions to the technical documentation of the simulation and can help support later usage of the simulation.

Status Reports

The User should receive status reports on a regular basis from the V&V Agent through the M&S PM and the Accreditation Agent respectively. These reports should summarize V&V and accreditation activities and cost accrued. Although some variance between actual and planned performance and events is acceptable, the User should take immediate action in concert with the M&S PM if the reports show an adverse trend.

VV&A History

Although only the documentation pertaining to problem and user domain requirements and the accreditation decision for the intended application is generated by the User, the User should recognize the importance of maintaining a complete history of VV&A information and work to ensure that an accurate, comprehensive record of all VV&A activities is kept. Documentation on any legacy simulation should include at least:

M&S VV&A Information for a Legacy Simulation
• Problem statement
• M&S approach statement, including status of existing simulation
• M&S requirements description, including measures and acceptability criteria

[38] See the RPG templates on Common VV&A Product Formats for additional information on VV&A products.

M&S VV&A Information for a Legacy Simulation
• Simulation conceptual model description, including modifications
• Design, including modifications
• V&V plan, including tasks, techniques, scenarios (use cases)
• Accreditation plan, including accreditation information needs
• Validation data
• Requirements Verification report
• Simulation conceptual model Validation report
• Design Verification report
• Implementation Verification report
• Validation report, including data V&V, testing, results validation
• Accreditation Assessment report
• Accreditation Decision statement

Two major reasons for maintaining this information are

- **Accountability**. A well-documented VV&A history provides a record of how and why decisions were made in the application process. This information can describe the rationale behind the original development, any subsequent modifications, and previous uses. A well-recorded VV&A history is invaluable when challenges are raised regarding its capabilities and limitations.
- **Model reuse.** By keeping an archive of VV&A activities during simulation development and application, its fitness for reuse in new applications should be much easier to assess.

The documentation should be specific enough to demonstrate the rigor of all V&V and accreditation activities and comprehensive enough to fully describe the application, the modifications to the simulation and data, the constraints and limitations placed on the simulation, and the overall VV&A process. Because legacy simulations are normally maintained under configuration control, the documentation should be prepared in keeping with any established forms and formats to facilitate their incorporation.

Cost Implications And Resourcing

Cost Factors

Preparing and accrediting a legacy simulation for a new use will always involve some investment of time and resources. Factors that impact the amount of this investment include:

- application-related factors [p. 41
- simulation-related factors [p. 41

Application-related Factors

The credibility demanded by the User for the application shapes the V&V and accreditation efforts. Credibility is directly related to operational risk. If the operational risk is great, the user will demand proof that the simulation is fit for use (credible). In general, the greater the operational risk, the more evidence should be accumulated to establish the simulation's fitness for use.

A clear and complete description of the overall problem and how the simulation will be used to help solve that problem are essential to structuring a cost-effective VV&A effort. The quality of the problem definition, requirements identification, and planning has a direct impact on understanding how the legacy simulation can be applied. This, in turn, impacts the amount of verification and validation that must be done to ensure sufficient evidence is available for the accreditation assessment. Ambiguous objectives, inconsistent requirements, and incomplete planning can result in implementation delays and lead to undertaking additional V&V tasks that increase costs and reduce the amount of time available for the accreditation assessment.

Simulation-related Factors

Knowledge of the status of the legacy simulation and how much modification is required will greatly help determine what specific V&V activities will provide the evidence needed for the accreditation assessment. In general, V&V and assessment activities for legacy simulations can normally draw extensively upon records of prior usage to provide much of the information needed for the assessment.

One key to minimizing costs with legacy simulations is the completeness and accessibility of its history. If the simulation's history is readily available (e.g., under configuration management and/or recorded in the M&S Resource Repository (MSRR) on the World Wide Web), then necessary information can be obtained for relatively little cost. However, if simulation documentation is incomplete or unavailable, additional time and resources will be needed to locate or generate the necessary information.

Manpower

The amount of time available for the accreditation assessment impacts the amount of manpower and resources required. If there is a short suspense, additional manpower may be needed to complete the assessment (e.g., additional technical personnel to conduct tests and gather results; SMEs and analysts to assist with the assessment; administrative personnel to prepare reports).

The experience of the people involved and their knowledge, skill, and capabilities relative to their specific V&V tasks determine how much time and training are needed to bring people up to speed.

> Example:
>
> Selection of participants in the accreditation effort can have major cost impacts. Participants who do not have the right experience or background or who cannot provide the time to prepare for and participate in assessment activities can lead to unnecessary work by others, last minute workarounds, disruptions, delays, and compromised assessments.

Tools

Tools and technology are also factors that can impact costs. Tools should be carefully selected so the savings involved in using them is greater than the cost of purchasing, training, and maintaining them. Ideally, the tools and technology associated with legacy simulation are well known and available. Documentation should also be available providing guidance on their use. Special consideration should be given to ensure tools are useful for both modification and V&V activities,[39] and tools that have been used on the simulation in the past. Selecting a tool that was used during the initial development or recent modification of a legacy simulation would be more cost effective than selecting a new tool with all the concomitant costs of initializing it.

Knowledge Acquisition Products

Knowledge acquisition (KA) products, e.g., functional descriptions of the battle space, can be the single most expensive part of the modification and the assessment. If an archive of validated functional descriptions pertaining to the problem space is available, KA costs can be reduced. Good documentation on the functional descriptions can also reduce the level of effort needed for verification and validation activities.

Cost Estimation

Cost estimation for both V&V and accreditation is complex and has a number of dependencies that link to analysis of historical information for legacy simulations. The V&V and Accreditation Agents should prepare cost estimates and provide them to the User for review. The User does not need to be an expert on cost estimating but should become sufficiently familiar with the cost estimating tools and processes used to ensure the resulting plans will provide the information needed to support the accreditation decision.

Cost estimation focuses on those factors that most directly impact the risk or uncertainty of the project. Additional costs should be considered as well:

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[39] See the reference document on V&V Tools for additional information.

- specialized tools
- use of SMEs for particular tasks
- travel and TDY costs
- specialized training
- special computers or devices
- communications and networking equipment
- maintenance contracts, licenses, etc.

These costs should be added to the cost matrix after adjustments and calculations have been made since they are not affected by risk or uncertainty of the project itself.

Cost Controls

Working with the Accreditation Agent and V&V Agent, the User can take a number of steps to control costs:

- Provide a clearly defined problem statement and objectives including specific M&S requirements and credibility needs
- Conduct a problem analysis to refine M&S requirements, analyze objects and behaviors identified in the requirements description, and determine which are most critical (i.e., have the largest impact on simulation outputs)
- Participate in risk analyses conducted by the Accreditation Agent and/or the M&S PM to identify and prioritize risks; conduct additional risk analyses periodically to ensure the program remains focused
- Ensure the Accreditation Agent has appropriately scoped the accreditation by identifying adequate and sufficient information needs and priorities that will focus the V&V effort on the most critical objects and behaviors
- Ensure all planning is detailed, thorough, and coordinated. A well planned V&V effort that is coordinated with the modification plan can be expected to more than pay for itself by reducing errors and rework
- Determine an appropriate level of tolerance of errors pertaining to the critical objects and their behaviors and balance it with error tolerance in other less critical functions

Documentation standards can benefit both current and future Users. These standards can reduce preparation time, help ensure that appropriate, complete information is provided, and reduce the time needed for reviews and editing. Documentation standards will allow future users to rapidly find the particular information elements they need.

References

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Muessig, Paul, Dennis Laack, and John Wrobleski, An Integrated Approach to Evaluating Simulation Credibility. Proceedings, Summer Computer Simulation Conference, Vancouver, BC, July 2000.

RPG References in This Document

select menu*:* *RPG Core Documents*, select item: "Accreditation Agent Role in the VV&A of Legacy Simulations"

select menu: *RPG Core Documents*, select item: "Supporting Roles in the VV&A of Legacy Simulations"

select menu: *RPG Core Documents*, select item: "V&V Agent Role in the VV&A of Legacy Simulations"

select menu: *RPG Core Documents*, select item: "VV&A of Legacy Simulations Overview"

select menu item: "Key Concepts"

select menu item: "RPG Glossary"

select menu*:* *RPG Reference Documents*, select item: "M&S Data Concepts and Terms"

select menu*:* *RPG Reference Documents*, select item: "T&E and V&V Integration"

select menu*:* *RPG Reference Documents*, select item: "V&V Tools"

select menu*:* *RPG Special Topics*, select item: "Conceptual Model Development and Validation"

select menu*:* *RPG Special Topics*, select item: "Data V&V for Legacy Simulations"

select menu*:* *RPG Special Topics*, select item: "Fidelity"

select menu*:* *RPG Special Topics*, select item: "Measures"

select menu*:* *RPG Special Topics*, select item: "Requirements"

select menu*:* *RPG Special Topics*, select item: "Risk Assessment and Its Impact on VV&A"

select menu*:* *RPG Special Topics*, select item: “Subject Matter Experts and VV&A”

select menu*:* *RPG Templates*, select item: “Common VV&A Product Formats”

select menu*:* *RPG Templates*, select item: “Data Quality Templates”

In the web-based version of this document, the appendix below appears as a hot link in the Preliminary User Activities (*Select Legacy Simulation*), and Primary User VV&A Support Activities (*Determine Sufficiency of Available Information)*.

Appendix A: Legacy Simulation Information Sources

Where To Find Information For A Legacy Simulation and What To Do With It

The following table [derived from Muessig, et. al] provides some insight into the issues revolving around simulation credibility and accreditation, what types of information are typically used to address the issues, and where that information might be found. This collection of information is based upon the experience of the Joint Accreditation Support Activity (JASA) in conducting accreditation support for acquisition programs. Legacy and modified legacy simulations were the M&S tools of interest in all of these programs.

Items Required	Item Description	Typical Sources
Credibility Issue: Does the simulation do what you need it to do?		
• Functional breakdown • Description of model	Describes what the model actually does including • M&S functions and relationships between functions • level of fidelity at which each function is modeled • function level input and output (I/O) and I/O relationships between functions • hardware, software and training needed to operate the model properly and interpret the output correctly	• user documentation (user programmer, and analyst manuals) • software design documentation, possibly including data flow diagrams • conceptual model documentation
• Limitations due to assumptions and errors	Describes model assumptions and known errors, and assesses their impact on model use. The resulting limitations should be correlated with each of the functions in the functional breakdown, but may also be useful at the overall simulation level. Should identify assumptions and/or errors of each M&S function (or of the model as a whole) that are implicit or explicit in the model's design and/or coding, as well as the implications of these limitations on appropriate or acceptable uses of the simulation.	• software design documentation and user documentation are the most typical sources of inherent assumptions and limitations arising from the algorithms used • configuration management databases are useful for known errors • change requests • some assumptions and limitations may be found in verification or validation reports but may not be explicitly stated as an assumption, limitation or error

Items Required	Item Description	Typical Sources
Credibility Issue: Do you have confidence that the simulation is being run properly?		
• Simulation portability across platforms (computer hardware and operating system suitability)	Test results that show that the hardware and operating systems used to host the simulation (if different than that used to develop the simulation) will allow it to run correctly and produce consistent results across platforms.	• usually found in the user documentation associated with the simulation or can be obtained from test results when documentation is not available
• Operator qualifications	Information to demonstrate that the operators have the expertise and knowledge to properly set up the simulation, execute it, and operate all associated tools and utilities. Typical information includes experience with the specific model being used, formal training on the model, and experience with the hardware, software, and interface devices being used.	• biographies or interviews with the operators
Credibility Issue: Can you convince others of your interpretation of simulation outputs?		
• Analyst qualifications	Information to demonstrate that the analysts using the simulation have the expertise and knowledge to properly generate the input data and interpret the outputs. Typical information includes experience with the specific model being used, formal training on the model, experience in performing similar analyses, and experience or training in simulation-based analysis techniques.	• usually gathered from biographies or interviews with the analysts or may be found in prior accreditation assessment reports
• Demonstration of pre- and post-processor acceptability	Information that shows that any auxiliary tools and utilities used to format or load input data, or to convert, record and visualize model outputs are suitable for the intended purpose(s). The type of information usually presented includes descriptive documentation of the tools and utilities being used for these purposes.	• user documentation associated with the simulation may list tools and utilities that are comparable with it • user documentation for the tools and utilities may contain information that will aid the determination of tool compatibility with the simulation
How much confidence do you have in the accuracy of the software?		
• Software development process description	The process description should include: • description of the development paradigm and how it is being implemented (including the use of CASE tools) • a logical process for defining tracing, and testing requirements throughout development • configuration management during the development process • adequate provision for documentation of all of	• software development plan or a configuration management plan that outlines the development process used If the development is underway, these plans should describe the process currently being used.

Items Required	Item Description	Typical Sources
	these activities	
• Software development resources description	The resource description should include: • a description of the hardware environment and the software engineering tools that will be/were used • qualifications of the personnel who will/did code the software and perform configuration management functions • who will be/was responsible for production of key documentation and testing • history of similar simulation development experience	Information should be provided in the software development plan or other management plans. If not documented, discussion with the software developers and managers is necessary to obtain as much information as possible, even if anecdotal. SEI Capability Maturity Model (CMM) evaluation report can provide evidence of simulation development qualifications.
• Software development artifacts	Simulation development artifacts that provide evidence (usually documentary in nature) that software development is actually being implemented in accordance with the guidelines and specifications called out in the software development plan (or its equivalent). Documentary artifacts should comply with known (or acceptable) standards and practices for format, content, currency and applicability to the current versions of the software.	• standard simulation documentation that reflects the current state of the software and that conforms to known standards of information content (e.g., configuration management histories and logs) • model documentation (user, programmer and/or analyst manuals) • software design documentation • documented set of requirements and conceptual model
• Software development results	V&V results include all evidence that the code has been developed according to the design and is free of critical errors, including reports from • design reviews • code walk-throughs • regression testing on model changes • software testing • supplemental V&V efforts of previous simulation users.	• requirements trace reports • reports of design reviews, peer reviews, and/or logical reviews • code walkthrough reports • software problem change request logs • module software test reports • subsystem software test reports • system software test reports
• Software management process description	The process description should include • a description of the post development management of the software • processes for documenting, implementing, tracking and testing simulation changes resulting from either requirements changes or software errors	M&S life cycle activities should be addressed in • software management plan • configuration management plan • V&V plan

Items Required	Item Description	Typical Sources
	Processes should also exist for keeping all software documentation current with the software.	• accreditation support plans Simulations developed within the Army should have a Simulation Support Plan (SSP).
• Software management resources description	The resource description should summarize the nature and extent of resources currently being applied to simulation management and support. The information should indicate whether sufficient funding and experienced personnel are being applied to ongoing documentation support, configuration management support, regression testing, user group support, training, technical support, etc.	Information should be included in management plans. If this information is not in existing documentation, discussion with the model managers and/or software developers is necessary to obtain as much of this information as possible, even if anecdotal.
• Software management artifacts	The term *artifact* refers to the evidence (usually documentary in nature) that software maintenance is actually being conducted in accordance with the guidelines and specifications called out in the simulation management plan (SMP), SSP, or its equivalent.	• configuration management database status reports, software change requests (SCRs) and/or system trouble reports • up to date model documentation (users, programmers and analysts manuals) • Configuration Control Board (CCB) and user group meeting minutes • updated software design documentation
• Post-development software V&V results		• software program change request (SPCR) logs that correlate V&V results with specific versions of the software • alpha or beta test reports for both new requirements testing and regression testing • specific verification reports for the simulation version being used • history of successful usage in similar applications
How much confidence do you have in the quality and suitability of input data obtained from outside sources?		
• Data quality profile	A body of metadata (data about the data) that describes the data or database, its source, specifications, intended use, history, and method of collection. Metadata elements should exist at the	• metadata elements should be available from the data producer or may exist in the same archives that contain the database itself

Items Required	Item Description	Typical Sources
	database, data element, and data value levels.	
• Independent assessment of data quality	An independent assessment is prepared by the data user when the data quality profile is inadequate, incomplete, or does not exist. This assessment addresses the key metadata elements in the data quality profile.	• Information that indicates the quality of test data can generally be found in documents such as test plans, laboratory procedures, calibration records, test records, etc • Information that indicates the quality of data collected through surveys or monitoring operations can generally be found in data collection plans, reports, and raw notes
• Data manipulation verification	This item refers to the verification of any data manipulation done by the user. Data manipulation includes operations such as editing, subset selection, merging, aggregation, transformation (from one coordinate convention to another, for example, or one set of units to another), estimation, interpolation, etc. Verification includes any activities that are done to ensure that the data manipulation steps are correct and do not introduce unknown errors.	• Verification of data manipulation procedures may be documented in verification reports (when done in conjunction with simulation development). • data manipulation verification performed as part of the simulation accreditation process should be included in the accreditation report. Documentation should describe the verification techniques that were used.
How much confidence do you have in the quality and suitability of self-generated input data?		
• Quality assurance process for self-generated data	An assessment of the process, equipment, tools, instrumentation, etc. used in generating the data. This assessment should generate information similar to that included in the critical metadata elements of the data quality profile.	• Information that indicates the quality of test data can generally be found in documents such as test plans, laboratory procedures, calibration records, test reports, etc. • Information that indicates the quality of data collected through surveys or monitoring operations can generally be found in data collection plans, reports, and raw notes
• Description of data quality assurance resources for self-generated data	Refers to the verification of any data manipulation done following receipt of the data by the User. Data manipulation includes operations such as editing, subset selection, merging, aggregation, transformation (e.g., from one coordinate convention to another, from one set of units to another), estimation, interpolation, etc.	• verification of data manipulation or transformation procedures should be documented in M&S verification reports • other data manipulation may be reviewed and verified as part of the M&S accreditation

Items Required	Item Description	Typical Sources
	Verification of data manipulation includes any activities that are done to ensure that the data manipulation steps are correct and do not introduce unknown errors.	process and documented in the accreditation assessment report Documentation should describe the verification techniques that were used.
How much confidence do you have in the simulation outputs?		
• Benchmarking results	These document the results of comparisons between simulation or simulation component outputs and those of a "standard" or widely accepted, comparable simulation or component. Benchmark results should include • the name and source of the standard simulation • why it is (or should be) considered a "reference" simulation • which parameters between simulations (or simulation components) were compared (and why) • what the results of the comparison were • what these results imply about the credibility of the outputs from the simulation under review Benchmark simulations generally possess greater credibility than the simulation (or component) under review and may be characterized by a "stamp of approval" from a recognized authority or professional organization.	• benchmarking results are usually found in either a validation report, a briefing that describes the results of the comparisons, or an accreditation support package (ASP)[1] These reports would generally be prepared by previous users of the simulation. They might also be available through the model manager or in M&S repositories (e.g., DoD and individual Service Modeling and Simulation Resource Repositories [MSRR]). If these results are for a previous version of the simulation, there also should be discussion of changes between that previous version and the version under consideration, and the implication of those changes.
• Face validation results	Describe the results of subject matter expert opinions about simulation realism and accuracy. This should be based on a structured review of simulation (or component) outputs, sensitivities, and/or design. When face validation is a review of the simulation design, the documentation should state whether the representations are realistic and whether any assumptions that underlie the design are acceptable from the perspective of the intended use. Documentation should describe which aspects of the simulation were reviewed (and why), who participated in the review, why one should trust their opinions (e.g. qualifications of the reviewers), what the results of the review were,	• face validation reports, ASPs, or accreditation assessment reports (when the face validation was done as part of an accreditation assessment) • simulation design validations may be reported in a design verification report (either a formal report or a briefing). These reports would generally be prepared by previous users. They might also be available through the model manager or an M&S repositories If these results are for a

[1] The ASP is used in the JASA accreditation process and the AF Toolkit.

Items Required	Item Description	Typical Sources
	and what these results imply about the credibility of the simulation.	previous version of the simulation, differences between that previous version and the version under consideration and the implication of those differences should be considered.
• Results validation documentation	Describes the results of comparisons between simulation (or simulation component) outputs and data collected from tests or from operation of the real system(s) or process(es) being simulated. The documentation should include a description of the source data used in the comparison, from where and how it was obtained, and why it should be considered representative of the real world. Issues relating to data quality (e.g. instrumentation accuracy, calibration, test scenario realism, etc.) should be addressed in the validation report. The correlation between simulation outputs and real world data should be stated in quantitative terms if this is possible with a qualitative explanation of what the quantitative measure implies. Anomalies and their impact on model usage should be explained.	• Results validation is typically documented in a validation report, accreditation assessment report or ASP. • In some cases, results validation might be documented with an annotated briefing prepared by the simulation developer or previous users, but may also be available through the model manager or M&S repositories. If these results are for a previous version of the simulation, differences between that previous version and the version under consideration and the implication of those differences should be considered.

Obtaining Oral Testimony

Locating information about a legacy simulation often involves talking with the people associated with its development, its maintenance, or its usage. It is important to ask the right questions.

- Engineers/analysts/programmers/scientists doing the simulation development tend to under-report the amount of V&V they have done, primarily because they tend not to use the terms “verification” and validation.” They tend to perform the kinds of tasks that V&V and Accreditation Agents call verification and validation as just a part of sound engineering practice. If asked what verification or validation has been performed, they may say, “nothing.” But if asked what was done to ensure that the simulation satisfied the specifications, performed as expected, or provided an appropriate level of realism, they will provide engineering notebooks describing tests or computer displays showing comparisons between the simulation and test data.
- Those who maintain a simulation almost always have a system for managing changes and maintaining control of the simulation even though it may not be called “configuration management.” If asked about “the configuration

management plan," they may say there is none; if asked how changes are tracked, they often describe a well thought out, practical system for documenting changes and model versions.

Another key is to ensure there is documentation to corroborate the discussion.

- Conscientious Developers often keep wonderful engineering notes that may be undervalued because they are not formally documented. However, such notes may be more useful than more formal model documentation because they provide more technical content.
- Managers or users may not be able to provide specific technical information. They may not have complete knowledge of the V&V tasks performed, software engineering practices followed, the SEI CMM level, etc.

Simulations in the Military Acquisition Process

If the item being modeled is a military system, and the simulation was developed as a tool as part of the acquisition process, there are several possibilities for gathering information on the simulation.

- The simulation documentation and V&V information may have been deliverables in the contract for development of the military item. The contracting officer's technical representative should have a copy of all the deliverables under the contract or know where to get them.
- If a government agency had oversight (e.g., technical direction agent [TDA]), they may have been doing testing on the simulation including comparisons with test data as the acquisition program progresses. This can be a tremendous source of validation results and understanding of the assumptions and limitations of the simulation that may not be written down anywhere. Interviewing these folks can be very fruitful. It is also often the case that the government team has the most corporate knowledge of the simulation because there is often less turnover on the government teams than on the contractor teams.
- There may also be a simulation working group or M&S integrated product team (IPT) whose minutes or informal records can be a good source of information.

Another source of simulation information may be the system being simulated. During the development of a complicated system (military or otherwise), modeling and simulation is often employed as a tool. Before expensive tests are conducted, simulations may be used to make pre-test predictions. The M&S predictions may be included in the data presented at test readiness reviews. In addition, simulations may be run after the test using the actual test conditions to compare to the test data. This may be done specifically for simulation validation, or simply to help the Developer

understand what happened in the actual test. Results of these comparisons may be included in the test readiness after action reports.

If the simulation is of an actual item being developed (military or otherwise), a review of the simulation may be held as part of the preliminary design review (PDR) or the critical design review (CDR) of the actual item. Most companies and organizations keep archives of presentations given at PDRs and CDRs and have careful records of conclusions reached at these reviews. This can be a very useful source of documentation of the simulation itself, results of any V&V conducted, and conclusions about the maturity and of credibility of the simulation by the review participants.

In the web-based version of this document, the appendix below appears as a hot link in the Preliminary User Activities (*Identify Measures of Success*) and Matching the Legacy Simulation to the Problem (*Measuring Success*) sections.

Appendix B: Simulation Acceptability Criteria Examples

This document provides some notional examples of assessment methods and acceptability criteria for sample M&S requirements.[1] The following table lists a selection of sample M&S requirements that includes programmatic requirements (e.g., policy compliance requirements), from the user domain; technical requirements,[2] from the problem domain; and usability requirements from the simulation domain.[3] This selection is not intended to represent a complete set of requirements. Rather, it is hoped that these examples will give readers some ideas that can be tailored to their own needs.

The table lists an assessment method and an acceptability criterion for each requirement. The ***assessment method*** is the method used (or intended to be used) to evaluate the characteristics of the simulation or its input against the requirement. An ***acceptability criterion*** is the pass/fail condition or standard that the simulation or input data needs to meet to satisfy the requirement. For some requirements, the table also provides ***auxiliary evidence***. Auxiliary evidence supports but is not the primary means of establishing compliance with the requirement. It is used whenever possible to increase confidence that the requirement is being satisfactorily addressed.

M&S Requirement and Acceptability Criteria Examples		
Assessment Method	**Acceptability Criteria**	**Auxiliary Evidence**
Programmatic Requirement: ***The Accreditation Process will follow SECNAVINST 5200.40.***		
The accreditation support agent will review the accreditation support plan and inspect the accreditation case to ensure that each requirement in SECNAVINST 5200.40 has been addressed.	The accreditation case ill address each requirement in the SECNAVINST to the satisfaction of the accreditation support agent. A table will be provided at the expert review of the accreditation case indicating how each requirement of SECNAVINST 5200.40 has been addressed.	The accreditation authority's representative will have an opportunity to review and sign the accreditation support plan and to participate in the expert review.
Usability Requirement: ***Personnel qualified to run the simulations and analyze the simulation output must be available.***		

[1] These examples are taken from accreditation support work conducted by the Joint Accreditation Support Activity (JASA) for military acquisition programs.

[2] The technical requirements in these examples are relevant to engineering level simulations and their input data.

[3] See the special topic on requirements for additional information.

M&S Requirement and Acceptability Criteria Examples		
Assessment Method	**Acceptability Criteria**	**Auxiliary Evidence**
Individuals will be selected based upon their M&S and analysis experience, expertise in use of the M&S, and knowledge of the actual weapon system being represented and the simulations.	Individuals assigned to conduct simulation runs and analysis of output will be recommended by the M&S team lead and approved by the weapon system program manager.	Qualifications of personnel conducting the simulation runs and analysis will be available upon request from the weapon system program office.
Usability Requirement: ***Output for any given run shall contain all information necessary to reconstruct the run including simulation version number and input file parameters.***		
Inspection of output filenames and content.	Experienced analyst can reproduce run from content and/or filename of output file.	
Technical Requirement: ***The M&S shall be capable of performing Monte Carlo runs on key parameters. Exact run list will be determined by mutual consent of the customer and the analysts doing the simulation runs.***		
Comparison of the list of parameters that can be varied in Monte Carlo fashion with the list of those that the final analysis plan indicates are to be varied.	Simulations have the capability of varying those parameters that the final analysis plan indicates are to be varied.	Documentation of Monte Carlo capabilities of the simulation is available.
Technical Requirement: ***The M&S shall be capable of accepting input data characterizing a particular missile flight test.***		
Inspection of documentation of post-flight analysis for at least one test flight.	Analysis team is able to perform post-flight analysis/reconstruction with the simulations using conditions of the actual flight test as input.	
Technical Requirement: ***Interaction of the weapons direction/control system with the missile during flight shall be represented such that the contents of the uplink command can be calculated.***		
Inspection of code.	Weapons Control System algorithms and missile algorithms and logic that calculate contents of uplink command are contained in the simulations.	Records of peer reviews between subject matter experts (SMEs) including the developer of the weapons control system concluded that the weapons control system algorithms were correctly instantiated in the missile simulation.
Technical Requirement: ***Simulation shall include variations in ship pitch and roll and the effect on egress of the missile from the missile launcher.***		

M&S Requirement and Acceptability Criteria Examples		
Assessment Method	**Acceptability Criteria**	**Auxiliary Evidence**
Inspection of missile simulation code to ensure that pitch and roll rates are included in simulation initialization. (Note: Pitch and roll of ship do not have a significant effect on launcher egress and are therefore not modeled. Pitch and roll rates, however, are part of missile initialization and are modeled.	Pitch and roll rates are included in simulation initialization.	
Technical Requirement: ***M&S shall model aerodynamics of the missile.***		
Post-flight analysis. Compare simulation predictions with TM for the following parameters: fin position and angle of attack for a given Mach number. See accreditation support plan for exact TM channels to be compared with these simulation parameters.	Simulation predictions shall match TM data to a degree that is acceptable to SMEs in the established program office simulation working group. (If an objective pass/fail number can be derived, or the SMEs can agree on a quantitative pass/fail criterion-- e.g. the predicted value of a particular parameter in the simulation must match the measured value from an instrumented test data to within x% of the measured value-- the quantitative criteria should be listed.)	Module level V&V on "AERO" adds validity to modeling in aerodynamic regions that do not occur in the flight tests examined. Aerodynamics is based on documented wind-tunnel tests.
Technical Requirement: ***M&S shall model propulsion including the thrust vector control system.***		
Post-flight analysis. Compare simulation predictions with TM for the following parameter: axial acceleration.	Simulation predictions shall match TM data to a degree that is acceptable to (SME)s in the established program office simulation working group.	Documented comparisons between simulation and static firing data.
Technical Requirement: ***M&S shall model the mass properties for the Mk xx configuration.***		
Inspection of code to confirm that mass properties are modeled. Inspection of simulation documentation to confirm that the source of the mass property data is documented.	Mass properties are modeled and source of data in simulation is documented.	Model level V&V of "PARAM" adds validity to mass property modeling. Mass property data is based upon mass estimates and measurements, both from the prime missile contractor. Mass property modeling in the version of the simulation used for this analysis will be checked against mass property documentation for production representative missiles.

M&S Requirement and Acceptability Criteria Examples		
Assessment Method	**Acceptability Criteria**	**Auxiliary Evidence**
Technical Requirement: ***M&S shall model the actuators.***		
Compare CAA module predictions of phase/gain and nonlinearities with bench test data on representative CAA unit. Post flight analysis. Adjust model to match the phenomenology caused by CAA misalignment (low amplitude roll, pitch and yaw, oscillations in the correct frequency).	Simulation predictions shall match bench test results to a degree that is acceptable to (SME)s. These tests have already been conducted by the actuator manufacturer.	See the description in the user's manual of the module level V&V conducted by the actuator manufacturer and the prime missile contractor. Note that the actuator model was developed by the actuator manufacturer.
Technical Requirement: ***M&S shall model the digital autopilot.***		
Post-flight analysis. Take input to the digital autopilot from the TM, run that input through the autopilot model, and compare output of the autopilot model with actual TM of output from the real autopilot during the flight test. (See results of the Flight 1 post-flight analysis and the Flight 1a anomaly analysis report.)	Simulation predictions shall match TM data from instrumented flight tests to a degree that is acceptable to SMEs in the simulation working group.	Module level V&V of "APSDM" adds validity to digital autopilot modeling.
Technical Requirement: ***M&S shall model the functions of the Inertial Measurement Unit (IMU).***		
Post-flight analysis. Compare simulation predictions with TM for the following parameters: accelerations and rates.	Simulation predictions shall match TM data from instrumented flight tests to a degree that is acceptable to (SME)s in the simulation working group.	Module level V&V of "IMUHIFI" adds validity to IMU modeling, particularly comparisons of module output with bench tests conducted by the manufacturer. Low frequency effects are based upon data from the IMU manufacturer. Modeling of high frequency effects are based upon data from several instrumented flight tests. Note: Although no requirements are listed for the IRU, IMU functions affect IRU performance, which affects missile performance. IRU functions are also checked in post-flight analysis.
Technical Requirement: ***M&S shall represent the known radar cross sections of test targets and current and expected threats as defined in the current edition of Ship Air Defense Systems (ONI--TA-012-xx) and the acquisition program integrated threat document.***		

M&S Requirement and Acceptability Criteria Examples		
Assessment Method	**Acceptability Criteria**	**Auxiliary Evidence**
Review documentation to confirm that all targets flown in test event these simulations are meant to support and all threats to be assessed using M&S are included.	Test target and threat signature data will be documented. Source of data for target and threat signature data will be documented. Differences between target and threat signature used in model runs and signature described in ONI and ITD documents will be disclosed and justified.	In many cases, data from the sources cited are not sufficient to support analysis. Any additions or augmentations to data from cited sources will be documented.

In the web-based version of this document, the appendix below appears as a hot link in the Documentation Requirements section.

Appendix C: VV&A Archive Information

The following table lists some of the major artifacts and products to be archived for future VV&A efforts.

Information to Consider Archiving for VV&A	
	Artifacts and Products
M&S Requirements	• definitions • metrics, measures,[1] and acceptability criteria • requirement trail through the simulation conceptual model and design to code • relationships to specific entities, processes, behaviors, events, or outputs • modifications/revisions required and accomplished
Planning	• problem definition and objectives • M&S development plan • V&V plan • data V&V plan • accreditation plan • modifications/revisions required and accomplished
Simulation Conceptual Model	• validated annotated conceptual model • behaviors and interactions[2] and associated data • sources of real world knowledge, data • verification techniques and results (e.g., data sources, interactions) • validation process and results (e.g., behaviors, conceptual model) • modifications/revisions required and accomplished
M&S Design	• annotated simulation designs, preliminary and detailed • design entities (e.g., objects, attributes, parameters) mapping to simulation conceptual model elements, objectives, requirements • verification techniques and results (e.g., functionality, data) • modifications/revisions required and accomplished
Implement and Test	• verified code • verification techniques and results (e.g., data, code) • testing techniques, data, scenarios (use cases), and results • data flow analysis • data validation techniques and results • results validation techniques, data, algorithms, scenarios (use cases), and results • modifications/revisions required and accomplished

[1] Measures of Performance (MOPs), Measures of Effectiveness (MOEs), etc. used to quantify each requirement. See the special topic on Measures for additional information.

[2] For example, the interaction of wind over the wing of an aircraft causing the aircraft to follow the laws of physics or tracing how command and control decisions are made (working backward from decision tables through to the sources of the information).

Information to Consider Archiving for VV&A	
	Artifacts and Products
Prepare for Use	• accreditation information needs • accreditation assessment process, results, and recommendations • accreditation report • modifications/revisions required and accomplished • constraints, limitations, assumptions associated with the application • results of execution

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